ADA

FUEL MAPS FOR THE GEP 6.5LT ENGINE WHEN OPERATING ON ATJ/JP-8 FUEL BLENDS AT AMBIENT AND ELEVATED TEMPERATURES

INTERIM REPORT
TFLRF No. 464

By
Douglas M. Yost
Edwin A. Frame

U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

For
Patsy A. Muzzell
U.S. Army TARDEC
Force Projection Technologies
Warren, Michigan

Contract No. W56HZV-09-C-0100 (WD30)

April 2015

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14. ABSTRACT
A General Engine Products 6.5LT engine operating on either JP-8 fuel, or a JP-8/ATJ blend, appeared to operate satisfactorily for the ambient operating conditions, with similar peak torque values and similar engine efficiency across the speed and load range evaluated. At the desert operating conditions there were greater detrimental impacts on full load torque and engine efficiency with the JP-8/ATJ fuel blend than with the JP-8 fuel itself. The deviation in indicated torque between the test fuels was 3-percent, regardless of test temperature.

15. SUBJECT TERMS
JP-8, ATJ, Alcohol to Jet, Alternative Fuels, General Engine Products 6.5LT, Rotary Fuel Injection

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EXECUTIVE SUMMARY

This project evaluated engine performance using a JP-8 fuel and a 75/25 blend of JP-8 and an Alcohol To Jet (ATJ) blendstock in a General Engine Product 6.5L Turbocharged diesel engine at two inlet temperature conditions. The GEP 6.5LT engine represents legacy diesel engine design with indirect injection and a rotary, pump-line-nozzle fuel injection system that is fielded in large numbers. The engine was operated across a 36-point speed and load matrix.

For both engine maps with the JP-8 fuel and the JP-8/ATJ fuel blend, the GEP 6.5LT engine produced similar power with either kerosene test fuel at the ambient operating conditions. The reduction in torque with the JP-8/ATJ blend was around 3-percent at higher engine speeds. At the desert operating conditions the JP-8/ATJ fuel blend had a greater reduction in power than JP-8 at desert conditions.

The Brake Specific Fuel Consumption (BSFC) was very similar between test fuels at the ambient operating conditions, with the region of peak engine efficiency being similar in size. At the desert operating conditions the BSFC with the JP-8/ATJ fuel blend showed the greatest detrimental impact at high speeds and high loads. Both fuels exhibited worse BSFC at the desert operating condition than the ambient conditions.

The GEP 6.5LT engine exhibited decreased full-load torque and increased BSFC with both kerosene fuels at the desert operating conditions. The largest torque reduction was 9-percent for the JP-8 fuel, and around 12-percent for the JP-8/ATJ fuel blend, both at the desert operating conditions.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuel and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period September 2013 through April 2015 under Contract No. W56HZV-09-C-0100. The U.S. Army Tank Automotive RD&E Center, Force Projection Technologies, Warren, Michigan administered the project. Mr. Eric Sattler (RDTA-SIE-ES-FPT) served as the TARDEC contracting officer's technical representative and Patsy Muzzell served as the project technical monitor.

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ACRONYMS AND ABBREVIATIONS

° C	degrees Centigrade
° F	degrees Fahrenheit
ASTM	ASTM International
bhp	brake horsepower
BMEP	brake mean effective pressure
BSFC	brake specific fuel consumption
CI	corrosion inhibitor
cm	Centimeter
CRC	Coordinating Research Council
cSt	Centistokes
DCN	derived cetane number
DF-2	Diesel Fuel number 2
ft	Foot
HEFA	Hydro-treated Esters and Fatty Acid(s)
HP *or* hp	Horsepower
hr	Hour
in	Inch
in^3	cubic inch
JP-8	Jet Propulsion 8
kW	Kilowatt
L	Liter
lb	Pound
lb_f	pound (force)
lb_m	pound (mass)
m	Meter
mg	Milligram
mm	Millimeter
OEM	original equipment manufacturer
ppm	parts per million
psi	pounds per square inch
psiA	pounds per square inch, absolute
psiG	pounds per square inch, gauge
RPM	rotation(s) per minute
SwRI®	Southwest Research Institute®
SOW	Scope of Work
TACOM	Tank Automotive and Armaments Command
TARDEC	Tank Automotive RD&E Center
TFLRF	TARDEC Fuel and Lubricants Research Facility
TWV	tactical wheeled vehicle
TWVC	tactical wheeled vehicle cycle
WOT	Wide Open Throttle
WD	work directive

1.0 BACKGROUND & INTRODUCTION

The United States Department of Defense Operational Energy Strategy has outlined a goal “to diversify its energy sources and protect access to energy supplies to have a more assured supply of energy for military missions” [1]. In accordance with this directive, the U.S. Army had conducted extensive research to investigate alternative fuels viability in military equipment. This has included basic chemical and physical property investigation to identify surrogate fuel sources with similar properties as traditional petroleum fuels, to full scale equipment and fleet testing to determine resulting component and vehicle performance. This report covers investigation into the use of blended Alcohol to Jet (ATJ) based fuel and traditional petroleum derived JP-8 in an 8-cylinder, turbocharged, indirect injection, diesel engine. All work was completed by the U.S. Army TARDEC Fuels and Lubricants Research Facility (TFLRF), located at Southwest Research Institute (SwRI) in San Antonio, TX.

2.0 TEST OBJECTIVE

The objective of this test was to evaluate a V8-cylinder General Engines Products (GEP) 6.5L turbocharged engine, (herein referred to as the GEP 6.5LT), while using JP-8 and a 75% JP-8/25% ATJ blend to determine changes in engine performance and changes in quantity of the fuel consumed. The GEP 6.5LT engine represents a significant portion of the tactical vehicle fleet, and uses a fuel sensitive, rotary, distributor, pump-line-nozzle fuel injection system. This style of fuel injection system architecture is sensitive to fuel lubricity and fuel viscosity, thus fuel temperature. As such there is a desire to understand the impacts of military specific and alternative fuels on this engine’s performance and fuel consumption. As part of this investigation, detailed engine performance maps were determined for a synthetic fuel blend using the GEP 6.5LT engine. The engine testing was performed at both standard and elevated temperature desert-like operating conditions.

3.0 TEST APPROACH

Engine dynamometer tests were utilized to evaluate JP-8 and the JP-8/ATJ blend in the GEP 6.5LT engine. Prior to the dynamometer tests the test engine had the fuel injection system replaced with

new calibrated components and the fuel injection timing was set to the proper value. The fuel injection pump was broken in on the calibration stand prior to installation on the engine. After reassembly full load engine power curves were conducted using JP-8 to determine the controller values for the engine fuel maps. The results were then used to determine changes in engine fuel consumption performance as a result of operating on the JP-8 and the JP-8/ATJ fuel blend at ambient and desert operating conditions. The following sections cover the technical description of the engine, discussion of the JP-8 and JP-8/ATJ fuel blend chemical and physical properties, overview of the engine test cell installation, and an outline of the engine mapping matrix.

3.1 ENGINE DESCRIPTION

The engine used for the JP-8 and JP-8/ATJ fuel mapping was the GEP 6.5LT. The GEP 6.5LT is a 90-degree, V-configured, 8-cylinder turbocharged, pump-line-nozzle rotary indirect fuel injected engine, rated at 170 horsepower at 3400 RPM and 345 ft-lb of torque at 1800 RPM on JP-8 fuel. The GEP 6.5LT engine utilizes a Stanadyne DB2831 rotary fuel injection pump with Bosch single-hole pintle fuel injectors, and is not configured for exhaust gas recirculation (EGR) or exhaust emissions aftertreatment.

3.2 FUEL PROPERTIES

As specified in the Scope of Work (SOW) for this project, the desire was to evaluate a baseline petroleum distillate JP-8, followed by the 75/25 blend of JP-8/ATJ to determine changes in engine performance and fuel consumption as a function of the type of test fuel consumed and the engine thermal operating condition. The 75/25 blend of JP-8/ATJ was investigated in a prior work directive to find the maximum ATJ blend component that would result in a 40-cetane number finished fuel blend. The JP-8 was provided by TFLRF. Table 1 and Table 2 show the resulting chemical and physical analysis of the test fuels and blend evaluated and requirements cited by MIL-DTL-83133, Detail Specification: Turbine Fuel, Aviation, Kerosene Type, JP-8, NATO F35, and JP-8 +100. Table 3 shows the bulk speed of sound and bulk modulus data for the JP-8, 100% ATJ and 75/25 JP-8/ATJ test fuels.

Table 1. Neat ATJ, JP8, and ATJ Fuel Blend Chemical/Physical Properties

Test	Method	Units	MIL-DTL-83133H Limits	SwRI Sample ID CL13-5979 Results	SwRI Sample ID CL13-5980 Results	SwRI Sample ID CL14-6189 Results
				100% ATJ	JP-8	25% ATJ
Water Reaction	**D1094**					
Volume change of aqueous layer		mL	-	1 0	0 0	0 5
Interface condition		rating	1b	1b	1b	1b
Separation		-	-	2	2	2
Copper Strip Corrosion (100°C, 2 hrs)	**D130**	rating	1	1B	1A	1A
Smoke Point	**D1322**	mm	min 25	35 0	25 5	27 0
Saybolt Color	**D156**	-	report	28	29	27
Freeze Point (manual)	**D2386**	°C	-47 max	<-80	-60 0	-57 0
Electrical Conductivity v. Temperature	**D2624**					
Temperature		°C	-	22 2	21 9	23 9
Electrical Conductivity		pS/m	150-700	0	1110	470
JFTOT-Breakpoint	**D3241**					
Test Temperature		°C	260	260	260	260
ASTM Code		rating	<3	1	1	<1
Maximum mmHg		mmHg	25 max	0 0	0 0	0 1
Acid Number	**D3242**	mg KOH/g	0 015 max	0 007	0 007	0 008
Existent Gum	**D381**	mg/100mL	7 max	10	1	2
Density	**D4052**					
15°C		g/ml	0 775 to 0 840	0 7575	0 7950	0 7857
Kinematic Viscosity	**D445**					
100°C		cSt	-	0 75	0 68	0 68
40°C		cSt	-	1 48	1 31	1 34
-20°C		cSt	8 max	4 82	4 45	4 50
Lubricity (BOCLE)	**D5001**	mm	-	0 930	0 660	0 650
Lubricity (HFRR) at 60°C	**D6079**	µm	-	698	676	749
Fuel System Icing Inhibitor (FSII) Content at 24°C	**D5006**	vol %	0 07 to 0 10	0 00	0 09	0 09
Particulate Contamination in Aviation Fuels	**D5452**					
Total Contamination		mg/L	1 0 max	0 30	0 30	0 30
Total Volume Used		mL	-	1000	1000	1000
Distillation	**D86**					
IBP		°C	-	174 1	173 6	173 0
5%		°C	-	176 8	183 7	181 5
10%		°C	250 max	177 7	186 9	183 5
15%		°C	-	178 1	189 3	185 3
20%		°C	-	178 2	192 0	187 1
30%		°C	-	179 2	197 1	191 3
40%		°C	-	175 8	202 1	195 4
50%		°C	-	180 5	206 5	199 6
60%		°C	-	181 4	211 5	205 3
70%		°C	-	183 6	217 2	212 3
80%		°C	-	189 9	224 0	221 5
90%		°C	-	214 8	234 1	233 8
95%		°C	-	241 9	242 5	243 2
FBP		°C	300 max	259 1	253 5	254 5
Residue		%	1 5	1 3	1 3	1 4
Loss		%	1 5	0 6	0 3	0 5
T50-T10		°C	-	2 8	19 6	16 1
T90-T10		°C	-	37 1	47 2	50 3

Table 2. Neat ATJ, JP8, and ATJ Fuel Blend Chemical/Physical Properties (Continued)

Test	Method	Units		SwRI Sample ID CL13-5979 Results	SwRI Sample ID CL13-5980 Results	SwRI Sample ID CL14-6189 Results
				100% ATJ	JP-8	25% ATJ
Flash Point (Pensky Martin)	**D93**	°C	min 38	44 5	53 5	51 5
Cetane Index	**D976**	-	-	53 9	49 2	50 2
Particle Count by APC (Cumulative)	**ISO-4406**					
>= 4µm(c)		class code	-	16	17	18
>= 6µm(c)		class code	-	15	15	16
>= 14µm(c)		class code	-	12	12	14
>= 21µm(c)		class code	-	11	10	14
>= 38µm(c)		class code	-	7	7	13
>= 70µm(c)		class code	-	0	0	13
Heat of Combustion - Net Intermediate	**D4809**	MJ/kg	42 8 min	43 60	43 00	43 18
Sulfur-Mercaptan	**D3227**	mass %	0 002 max	<0 0003	0 0004	0 0003
Derived Cetane Number	**D6890**					
Ignition Delay, ID		ms	-	20 505	4 317	4 885
Derived Cetane Number		---	*	15 65	47 68	42 66
Cetane Number	**D613**	-	-	<19 4	47	41
MSEP	**D7224**	rating	-	93	57	55
Aromatic Content	**D1319**					
Aromatics		vol %	25 max **	0 7	16 8	13 7
Olefins		vol %		2 3	2 0	2 1
Saturates		vol %		97 0	81 2	84 2
Naphthalene Content	**D1840**	vol%	3 0 max	0 0	0 8	0 5
Hydrogen Content (NMR)	**D3701**	mass %	13 4 min	15 53	14 20	14 51
Sulfur Content	**D4294**	ppm	3000 max	<100	997	749
* Derived Cetane Number of 40 min per table A-II, ** Aromatic minimum of 8 per table A-II						

Table 3. Neat ATJ, JP8, and ATJ Fuel Blend Chemical/Physical Properties (Continued)

Test	Method	Units	SwRI Sample ID CL13-5979 Results		SwRI Sample ID CL13-5980 Results		SwRI Sample ID CL14-6189 Results	
			100% ATJ		JP-8		25% ATJ	
Speed of Sound @ 35°C	**SwRI**		**@**		**@**		**@**	
		m/s	184 psi	1,175 2	222 psi	1,264 8	413 psi	1,247 4
		m/s	756 psi	1,201 9	832 psi	1,294 4	870 psi	1,269 4
		m/s	1366 psi	1,230 8	1977 psi	1,326 6	1710 psi	1,307 8
		m/s	2015 psi	1,257 3	2816 psi	1,365 2	2473 psi	1,329 8
		m/s	3083 psi	1,308 1	3770 psi	1,393 1	3846 psi	1,378 7
		m/s	3808 psi	1,329 0	4990 psi	1,428 9	4838 psi	1,421 4
		m/s	4533 psi	1,356 9	5944 psi	1,453 8	-	-
		m/s	5563 psi	1,392 2	--	--	-	-
Speed of Sound @ 75°C	**SwRI**		**@**		**@**		**@**	
		m/s	222 psi	1,031 0	184 psi	1,108 3	222 psi	1,093 6
		m/s	794 psi	1,062 0	756 psi	1,133 0	794 psi	1,116 4
		m/s	1366 psi	1,094 7	1366 psi	1,168 2	1519 psi	1,151 1
		m/s	2053 psi	1,130 8	2511 psi	1,216 2	2511 psi	1,192 7
		m/s	2740 psi	1,157 9	3426 psi	1,245 8	2892 psi	1,215 1
		m/s	3541 psi	1,196 2	4571 psi	1,290 9	3541 psi	1,234 0
		m/s	4304 psi	1,225 2	5715 psi	1,319 8	4609 psi	1,281 5
		m/s	5334 psi	1,265 0	--	--	-	-
Isentropic Bulk Modulus @ 35°C	**SwRI**		**@**		**@**		**@**	
		psi	184 psi	149,859	222 psi	180,503	413 psi	173,700
		psi	756 psi	157,484	832 psi	189,866	870 psi	180,522
		psi	1366 psi	165,935	1977 psi	200,836	1710 psi	192,639
		psi	2015 psi	173,892	2816 psi	213,736	2473 psi	200,043
		psi	3083 psi	189,642	3770 psi	223,720	3846 psi	216,736
		psi	3808 psi	196,628	4990 psi	236,804	4838 psi	231,626
		psi	4533 psi	205,833	5944 psi	246,317	-	-
		psi	5563 psi	217,909	--	--	-	-
Isentropic Bulk Modulus @ 75°C	**SwRI**		**@**		**@**		**@**	
		psi	222 psi	111,354	184 psi	133,212	222 psi	128,337
		psi	794 psi	118,908	756 psi	139,986	794 psi	134,404
		psi	1366 psi	127,042	1366 psi	149,678	1519 psi	143,772
		psi	2053 psi	136,374	2511 psi	163,538	2511 psi	155,554
		psi	2740 psi	143,790	3426 psi	172,729	2892 psi	161,877
		psi	3541 psi	154,372	4571 psi	186,854	3541 psi	167,659
		psi	4304 psi	162,898	5715 psi	196,528	4609 psi	182,077
		psi	5334 psi	174,815	--	--	-	-

3.3 ENGINE INSTALLATION & TEST CELL

The GEP 6.5LT engine available was previously used for lubricant related fuel consumption studies at TFLRF, and was determined to be in good condition by inspection. The fuel injection system components were replaced with new components prior to the fuel map generation. Once the engine was selected and replacement components received, the engine was prepared and instrumented for the following list of parameters:

- Temperatures: description (data acquisition test point name)
  - Coolant In (TCOOLIN)
  - Coolant Out (TCOOLOUT)
  - Oil Galley Temp (TOILGALY)
  - Oil Sump Temp (TOILSUMP)
  - Air Before Compressor (TAIRBCOM)
  - Air After Compressor (TAIRACOM)
  - Fuel Inlet (TFUELIN)
  - Fuel Outlet (TFUELOUT)
  - Fuel Heater Loop Temp (TFUELHTR)
  - Exhaust Cylinder 1, 2, 3, 4, 5, 6, 7, 8 (TEXHCYL#)
  - Exhaust before turbo left bank (TEXHLBCK)
  - Exhaust before turbo right bank (TEXHRBCK)
  - Exhaust after turbo (TEXHAT)
  - Dry Bulb (TDRYBULB)
  - Dyno Water In (TDYNOIN)
  - Dyno Water Out (TDYNOOUT)
  - Day Tank Temperature (TDAYTANK)
- Pressures: description (data acquisition test point name)
  - Ambient (PAMBIENT)
  - Pressure before compressor (PINTBC)
  - Pressure after compressor (PINTAC)
  - Pressure intake restriction (PINT_RST)
  - Fuel pressure (PFUEL)

    - Oil galley (POILGALY)
    - Exhaust pressure after turbo (PEXHAT)
    - Coolant system pressure (PCOOL)
- Analog Inputs
    - Engine speed (SPEED)
    - Engine Torque (TORQUE)
    - Engine fuel consumption (FFUEL)
    - Blow-by flow rate (FBLOWBY)

Once instrumented, the engine was installed into TFLRF Test Cell 05 for testing. The following outlines the general setup of the engine and test cell installation:

- SwRI developed PRISM system was used for data acquisition and control.
- The following controllers were designed into the installation:
    - Engine speed
    - Throttle output
    - Coolant out temperature
    - Fuel inlet temperature
    - Air inlet temperature
    - Oil sump temperature
- The engine was coupled with a driveshaft and torsional vibration coupling to a Midwest model 1519 (eddy current) 500-hp wet gap eddy current dynamometer.
- Engine speed was controlled through dynamometer actuation, and engine load was controlled through an actuator operating a cable to the fuel injection pump rack.
- Coolant temperature was controlled using laboratory process water and a shell and tube heat exchanger. A three way process valve was used to allow coolant to bypass the heat exchanger as required to manipulate engine temperature to desired levels. The engine thermostat was blocked so that the external cooling system had full control over the engine temperature.
- Inlet air was drawn in at ambient conditions through two radiator type cores plumbed prior to the engines turbocharger inlet. The radiator cores were fitted with three way

process control valves and used segregated sources of hot engine coolant and chilled laboratory water to control the temperature of the incoming air charge.

- Engine oil sump temperature was controlled using laboratory process water and a flat plate counter flow heat exchanger. A two way process valve was used to allow regulation of the process water flow to manipulate oil sump temperature to the desired level.
- Fuel was supplied to the engine using a recirculation tank (or "day tank") at ambient temperature and pressure conditions. The recirculation tank was connected to the engine's fuel supply and return, and kept at a constant volume controlled through a float mechanism which metered the bulk fuel supply from the test cell to replenish the tank volume. This make-up fuel flow rate was measured by a Micro Motion Coriolis type flow meter to determine the engine fuel consumption.
- Fuel temperature was controlled by routing fuel leaving the recirculation tank through a liquid to liquid heat exchanger that supplied required heat transfer (in either direction) to the incoming fuel from a temperature controlled secondary process fluid. This secondary process fluid (ethylene-glycol and water mix) was heated and cooled as needed by an inline circulation heater and liquid to liquid trim heat exchanger connected to the laboratory chilled water supply.
- The engine exhaust was routed to the building's roof top exhaust handling system and discharged outside to the atmosphere. A butterfly valve was used to regulate engine exhaust backpressure as required during testing.
- Crankcase blowby gasses were ducted into a containment drum to capture any entrained oil, and then routed to the atmosphere through a hot wire flow meter to measure flow rate.
- The engine was lubricated with MIL-PRF-2104H SAE 15W40 engine oil.

Figure 1 shows the GEP 6.5L engine as installed in TFLRF Test Cell 05.

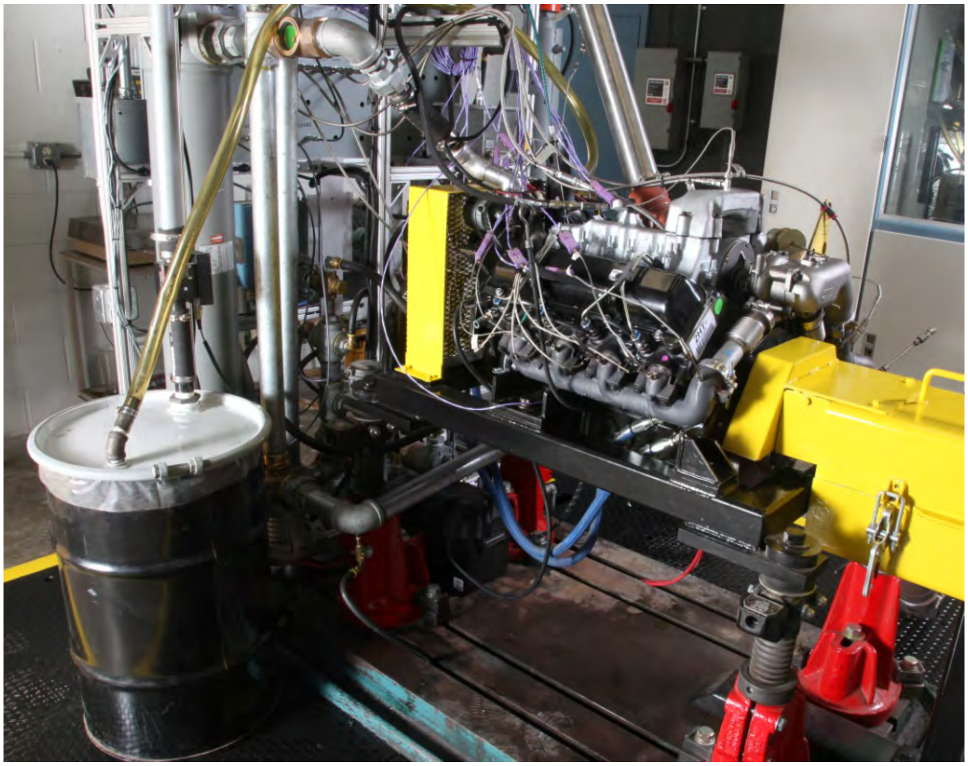

Figure 1. General Engine Products 6.5LT Installation, TFLRF Test Cell 05

3.4 TEST CYCLE

The PRISM data acquisition and control program was written, and the test stand was shaken down to test and tune all test load points and controllers for the fuel mapping runs. The controllers were set up and tuned to meet both the ambient and desert operating conditions. Table 4 shows the controller targets for both of the engine operating conditions.

Table 4. Engine Operating Conditions

Parameter	Ambient	Desert
Inlet Air Temp	77° +/- 4°F	120° +/- 4°F
Fuel Inlet Temp	86° +/- 4°F	145° +/- 4°F
Engine Coolant Temp	205° +/- 4°F	218° +/- 4°F

The statement of work indicated a fuel consumption engine map should be generated for a 36-point speed and load matrix. The engine map was developed for six engine speeds along the full load curve, from 1000 to 3400-RPM engine speed. The loads points varied at each speed from

10%-load to the full rack load at 18% load intervals. All the points off the full-load curve were run at constant load for better comparison of fuel consumption differences. The ambient JP-8 full load curve was used to generate the partial load set points at each engine speed. The target speed and load matrix is shown in Table 5.

Table 5. GEP 6.5LT Engine Mapping Performance Matrix

% JP-8 Ambient Load Setpoint	Engine Speed, RPM					
	3400	2920	2440	1960	1480	1000
--	100%	100%	100%	100%	100%	100%
82	212.7	241.1	261.1	277.2	262.0	216.8
64	166.0	188.2	203.8	216.4	204.5	169.2
46	119.3	135.2	146.5	155.5	147.0	121.6
28	72.6	82.3	89.2	94.6	89.5	74.0
10	25.9	29.4	31.8	33.8	32.0	26.4
JP-8 Ambient Full-Load Values, ft-lb	262.9	290.9	317.9	339.9	334.3	295.4

Prior to changing the fuel injection pump and injectors the fuel injection timing for the engine was determined with the old fuel injection system. The new calibrated fuel injection pump and injectors were installed, and the fuel injection timing of the new fuel injection system was set to the same values as the prior system. The test fuel blends, both the JP-8 and the JP-8/ATJ blend, were prepared.

4.0 DISCUSSION AND RESULTS

After a full-load curve was generated with JP-8, the testing was initiated with the JP-8/ATJ blend at ambient temperatures, followed by the desert condition temperatures. Table 6 and Table 7 show the ambient temperature operating condition summaries for the JP-8/ATJ fuel blend at the three higher engine speeds and the three lower engine speeds respectively. The observed engine power for the 36-point speed and load matrix for the JP-8/ATJ fuel blend is shown in Figure 2 for the ambient operating conditions. Figure 3 is the indicated torque for the JP-8/ATJ fuel blend across the speed and load matrix at the ambient engine conditions. The corresponding ambient condition fueling rates for the JP-8/ATJ blend are shown in Figure 4.

For comparison, Table 8 and Table 9 show the ambient temperature operating condition summaries for the JP-8 fuel at the three high engine speeds and three low engine speeds respectively. The observed engine power for the 36-point speed and load matrix for the JP-8 fuel is shown in Figure 5 for the ambient operating conditions. Slightly higher full-load power is seen with JP-8 because of the marginally higher fuel density. Figure 6 is the indicated torque for the JP-8 fuel across the speed and load matrix at the ambient engine conditions. The corresponding ambient condition fueling rates for the JP-8 fuel are shown in Figure 7. Because the partial loads points were performed at a constant set point for both fuels, the fuel delivery measurements reveals the most variations between fuels.

The desert temperature operating condition summaries for the JP-8/ATJ fuel blend at the three high engine speeds and three low engine speeds are displayed in Table 10 and Table 11 respectively. The observed engine power for the 36-point speed and load matrix for the JP-8/ATJ fuel blend is shown in Figure 8 for the desert operating conditions. The full-load power is decreased due to the elevated intake air and fuel temperatures. Figure 9 is the indicated torque for the JP-8/ATJ fuel blend across the speed and load matrix at the desert engine conditions. The full-load curve shows the effects of the elevated temperatures, particularly at high speeds. The corresponding desert condition fueling rates for the JP-8/ATJ blend are shown in Figure 10.

Table 6. Operating Condition Summary for GEP 6.5LT Engine with JP-8/ATJ Fuel Blend at Ambient Inlet Conditions and High Engine Speeds

Speed Setpoint	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
Load Setpoint	lb-ft	256.1	212.7	166.0	119.3	72.6	25.9	282.4	241.1	188 2	135.2	82.3	29.4	309.5	261.1	203.8	146 5	89.2	31 8
75% JP-8/25% ATJ Ambient Engine Performance																			
SPEED	RPM	3400	3399	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
TORQUE	lb-ft	256.1	212.8	166.1	119.4	72.1	25.9	282.4	241.1	188 3	135.2	82.4	29.3	309.5	260.9	203.8	146 3	88.9	31 9
POWER	BHP	165.8	137.7	107.5	77.3	46.7	16.8	157.0	134.0	104.7	75.2	45.8	16.3	143.8	121.2	94.7	68 0	41.3	14 8
FFUEL	lb/hr	85.05	70.89	58 24	48.48	38.67	29.98	71.11	61.23	49.95	40.49	32.03	22 86	60.81	51.03	41.08	32.22	24.44	16.52
BSFC	lb/BHP-hr	0.513	0.515	0.542	0.627	0.829	1.798	0.453	0.457	0.477	0.539	0.699	1.410	0.423	0.421	0.434	0.474	0 592	1.118
BMEP	psi	97.4	80.9	63.2	45.4	27.4	9.8	107.4	91.6	71.6	51.4	31.3	11.1	117.7	99.2	77.5	55.6	33.8	12.1
FBLOWBY	cfm	3.77	4.02	4 06	3.96	3 91	3.90	3.78	3.74	3.92	3.91	3.83	3.71	3.82	3.79	3.97	3.92	3.90	3.71
CELL_RH	%	37.8	31.4	28.7	26.7	27.7	27.3	25.2	24.6	23 9	23.1	23.5	22.7	23.3	22.8	21.7	21.1	20.4	21 5
Temperatures																			
TCOOLIN	°F	191.8	193.4	195.0	196.2	197.0	197.8	192.1	193.6	195 2	196.0	197.3	198.4	192.0	193.6	195.2	196 3	197.6	198 8
TCOOLOUT	°F	205.0	204.9	205.1	205.2	205.1	205.0	204.9	205.0	205.1	204.9	205.0	205.1	205.1	205.0	205.1	204 9	205.0	204 9
TOILGALY	°F	168.4	187.2	189.4	192.7	198.0	199.3	186.5	190.9	196 3	201.3	205.1	207.5	193.6	201.0	204.1	206.5	211.2	218.1
TOILSUMP	°F	235.0	235.0	235.0	234.9	234.9	235.1	235.0	234.9	235.1	235.0	235.1	234.9	234.9	234.9	235.0	235.0	233.9	233.6
TDRYBULB	°F	91.7	94.5	96.5	97.9	98.7	99.3	100.4	101.8	102 9	103.4	103.6	103.7	103.8	104.5	105.1	105.3	105.4	105 3
TAIRBCOM	°F	76.4	76.6	77.2	78.2	77.2	76.8	77.0	77.2	76 9	76.7	77.6	76.7	76.7	78.0	76.5	76.7	77.4	77 3
TAIRACOM	°F	172.9	161.4	154.4	154.0	151.5	156.6	168.7	162.6	161.7	161.4	163.6	158.5	178.6	178.8	176.7	170.5	162.2	150 2
TEXHLBCK	°F	1328.8	1161.2	1006.9	881.6	758.8	639.6	1200.0	1083.7	918.1	786.1	662.3	543.8	1129.7	987.3	826.5	693.4	571.1	459.4
TEXHRBCK	°F	1328.1	1166.0	1012.7	886.4	757.8	640.7	1205.4	1063.5	903 9	776.2	648.9	529.2	1124.8	969.3	813.0	669.9	555.2	442 3
TFUELHTR	°F	85.2	85.0	84.9	84.5	84.8	84.1	84.2	83.8	84 0	83.9	83.4	84.2	83.3	84.0	83.5	83.9	83.8	83.6
TFUELIN	°F	86.2	86.2	86.0	86.1	85.9	85.9	86.1	86.2	86 2	85.9	86.4	85.8	86.0	86.0	85.9	86.1	85.9	86 0
TFUELOUT	°F	121.4	121.8	121.9	122.0	122.1	122.9	119.7	120.0	119 8	119.6	120.2	120.7	117.0	117.8	118.4	118.8	119.3	119.7
TEXHAT	°F	487.8	453.1	397.8	369.6	341.1	310.9	433.7	445.3	399 8	358.2	308.3	270.9	419.1	424.1	371.9	315.8	269.9	229 5
TEXHCYL1	°F	1276.5	1164.8	1031.4	913.8	796.4	675.9	1137.7	1033.1	902 3	801.6	679.6	558.3	1046.6	927.4	798.6	674.2	566.6	451.6
TEXHCYL2	°F	1280.1	1121.7	975.3	881.5	770.6	665.9	1146.3	1018.9	887 0	766.4	660.5	557.1	1082.3	928.7	793.3	670.4	553.0	457 5
TEXHCYL3	°F	1290.5	1153.7	1004.0	886.3	766.4	652.8	1167.4	1046.5	899 9	785.3	663.1	540.6	1097.0	961.8	814.0	684.7	570.6	454.6
TEXHCYL4	°F	1330.6	1180.1	1026.3	901.9	786.1	666.6	1178.0	1085.7	931.6	808.3	686.5	571.5	1095.6	961.7	816.3	691.0	584.5	466 5
TEXHCYL5	°F	1266.0	1080.7	946.6	838.3	733.3	631.0	1158.0	1008.4	864.4	743.4	634.9	520.4	1068.5	904.0	764.8	644.2	540.3	428 5
TEXHCYL6	°F	1290.6	1123.7	978.8	867.6	747.1	631.1	1155.6	1039.4	879 5	756.6	637.3	533.0	1080.8	944.4	798.6	677.4	554.7	456 5
TEXHCYL7	°F	1248.2	1100.3	961.8	851.7	730.2	624.0	1122.2	989.8	848.1	731.7	619.6	514.9	1032.2	896.0	759.2	631.5	532.1	431.7
TEXHCYL8	°F	1269.6	1113.0	974.9	848.0	734.1	625.4	1149.7	1044.6	889.4	765.3	649.7	531.7	1068.9	951.5	799.4	678.5	563.8	450.1
TDYNOIN	°F	81.0	80.8	81.0	80.8	80.8	80.6	81.1	81.4	81.4	81.3	81.3	81.1	81.5	81.8	81.8	81.7	81.4	81 2
TDYNOOUT	°F	99.3	96.2	93.2	89.9	86.6	82.8	98.0	96.4	93 5	90.4	87.1	83.3	97.7	96.1	93.2	90.2	86.7	83 2
TDAYTANK	°F	85.9	87.0	87.7	88.1	88.4	89.1	88.7	89.5	90 3	90.5	90.8	91.1	90.0	91.0	91.7	92.0	91.9	91 0
Pressures																			
POILGALY	psig	47.4	46.6	46.0	45.7	45.0	44.7	44.3	43.9	43 0	42.7	42.4	42.3	41.1	40.0	39.7	39.5	39.4	39.1
PFUEL	psig	6.3	6.6	6.7	6.2	6.7	6.6	6.0	6.7	6.1	5.2	5.1	5.5	4.6	4.8	4.9	5.2	5.4	5.6
PAMBIENT	psia	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2
PINTBC	psia	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14 2
PINTAC	psig	5.7	4.7	4.0	3.9	3.8	4.2	6.1	5.5	5 5	5.4	5.5	5.1	7.8	7.7	7.6	6.9	6.0	4 9
PINT_RST	psig	0.15	0.14	0.13	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.10	0.09	0 09	0.09	0.08	0.08	0.07
PEXHAT	psig	0.28	0.24	0.20	0.14	0.12	0.11	0.24	0.19	0.15	0.13	0.12	0.12	0.18	0.16	0.14	0.12	0.11	0.10
PCOOL	psig	10.6	10.7	10.7	10.6	10.4	10.3	10.9	10.8	10.6	10.4	10.2	10.1	10.7	10.6	10.4	10.2	10.0	9 9

Table 7. Operating Condition Summary for GEP 6.5LT Engine with JP-8/ATJ Fuel Blend at Ambient Inlet Conditions and Low Engine Speeds

Speed Setpoint	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
Load Setpoint	lb-ft	332.8	277.2	216.4	155.5	94.6	33.8	327.8	262	204 5	147.0	89.5	32.0	288.9	216.8	169.2	121.6	74.0	26.4
75% JP-8/25% ATJ Ambient Engine Performance																			
SPEED	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
TORQUE	lb-ft	332.8	277.0	216.5	155.5	94.7	33.8	327.8	261.7	204.1	147.3	89.5	31.8	288.9	217.1	169.3	121.6	74.3	26.7
POWER	BHP	124.2	103.4	80.8	58.0	35.3	12.6	92.4	73.8	57 5	41.5	25.2	9.0	55.0	41.3	32.2	23.1	14.1	5.1
FFUEL	lb/hr	49.69	40.77	32.61	24.62	17 50	11.72	36.00	27.95	21.82	16.20	11.19	6 80	22.45	15.54	11.95	8.97	6.17	3.44
BSFC	lb/BHP-hr	0.400	0.394	0.404	0.424	0.496	0.932	0.390	0 379	0.380	0.390	0.444	0.761	0.408	0.376	0.371	0.388	0.437	0.684
BMEP	psi	126.5	105.3	82.3	59.1	36.0	12.8	124.6	99.5	77.6	56.0	34.0	12.1	109.8	82.5	64.4	46 2	28.3	10 2
FBLOWBY	cfm	3.97	3.91	3 94	3.79	3.64	3.45	3.75	3.69	3.61	3.59	3.41	3 36	3.54	3.55	3.60	3.55	3.44	3.36
CELL_RH	%	20.8	19.5	18.5	19.9	19.3	20.1	20.7	19.4	18 9	20.3	19.7	20.1	20.6	20.5	20.7	20 0	20.3	20 3
Temperatures																			
TCOOLIN	°F	191.2	193.5	195.3	196.9	198.5	199.6	190.6	193.3	195 3	197.6	198.5	200.1	189.2	193.9	195.6	197.6	198.5	200.7
TCOOLOUT	°F	205.0	205.3	205.3	205.2	205.2	205.2	204.8	204.9	204 8	205.4	204.9	205.4	204.8	205.2	204.8	205 3	204.8	205 3
TOILGALY	°F	195.3	204.7	203.3	209.9	215.5	226.3	205.5	208.5	207 0	224.3	210.8	231.3	203.6	221.8	225.5	208.6	225.4	222 8
TOILSUMP	°F	235.0	233.9	234.0	232.7	232.7	232.5	233.8	232.8	230 3	231.2	229.3	235.5	234.2	229.2	231.0	223.9	229.4	226 2
TDRYBULB	°F	104.9	105.2	105.5	105.7	105.5	105.3	105.1	105.4	105 5	105.5	105.3	105.0	104.7	104.9	105.1	105.1	104.8	104.6
TAIRBCOM	°F	78.0	76.3	77.0	77.1	75.8	77.4	76.4	76.9	77.7	76.6	76.6	78.2	75.8	76.9	77.4	77.7	76.0	77 0
TAIRACOM	°F	199.4	187.6	176.5	157.7	139.1	125.7	177.2	152.3	134.4	120.6	111.0	105.8	122.4	109.5	103.9	99.7	95.8	94 0
TEXHLBCK	°F	1036.9	896.0	763.4	620.9	492.2	376.6	989.4	828.8	677 2	533.9	411.3	304.4	966.5	710.7	550.1	432.1	333.8	252.1
TEXHRBCK	°F	1044.3	890.0	752.9	611.4	482.6	379.2	983.8	822.4	669 9	527.3	404.0	298.3	959.0	707.1	544.0	426.9	328.6	247 0
TFUELHTR	°F	83.6	83.9	83.6	83.7	83.6	83.7	83.6	83.8	83.4	83.7	83.0	83.0	83.6	81.7	83.8	82.3	80.5	84.7
TFUELIN	°F	86.1	86.0	86.0	86.0	86.0	86.0	86.2	85.9	86 0	85.9	86.1	85.8	86.6	85.9	85.7	86.5	85.8	85 2
TFUELOUT	°F	114.8	116.4	117.4	118.3	118.7	118.4	117.3	117.3	118 0	118.2	118.3	118.5	118.1	119.6	119.0	118.3	117.9	117 0
TEXHAT	°F	380.4	379.8	328.9	289.3	239.4	203.0	326.6	336.3	291 0	254.4	214.2	184.5	316.9	326.8	273.2	228.2	186.4	165.6
TEXHCYL1	°F	938.2	821.1	708.5	587.5	470.3	380.5	874.1	755.2	620 9	501.2	394.2	296.7	824.0	637.4	509.0	408.5	317.3	248.1
TEXHCYL2	°F	982.1	849.2	718.7	597.3	471.7	366.9	904.3	761.7	632.7	507.8	399.1	300.6	841.8	626.1	498.0	399.1	315.6	244 0
TEXHCYL3	°F	1008.6	879.5	755.0	629.3	503.1	397.2	936.9	810.8	671 9	542.2	424.8	314.8	891.3	701.2	551.0	440.7	348.0	263.6
TEXHCYL4	°F	980.6	848.2	738.2	617.1	494.8	386.7	914.0	777.8	649 9	524.7	412.7	312.4	865.2	651.6	526.0	423.6	332.3	256.4
TEXHCYL5	°F	977.7	827.9	707.7	586.3	467.3	365.9	905.3	759.3	628 3	502.9	390.7	293.7	847.2	635.6	509.9	414.6	324.3	250.4
TEXHCYL6	°F	981.9	850.0	723.1	597.9	478.6	365.1	918.9	765.8	629 8	506.4	395.1	297.2	872.1	647.7	519.5	417.5	324.4	249.4
TEXHCYL7	°F	961.6	819.5	694.4	569.8	458.1	362.2	877.9	722.8	599.1	481.0	373.3	280.7	831.5	613.9	482.9	383.3	298.9	228.7
TEXHCYL8	°F	976.4	856.0	738.8	600.9	482.6	371.0	906.0	770.1	636.7	511.9	397.7	294.7	871.2	663.7	518.2	413.8	322.6	246 3
TDYNOIN	°F	81.4	81.5	81.5	81.4	81.2	80.9	81.3	81.2	81.1	81.1	81.0	81.0	81.1	81.0	80.9	80.6	80.7	81 8
TDYNOOUT	°F	95.6	93.7	91.2	88.5	85.6	82.6	91.9	89.8	88 0	86.0	84.1	82.1	87.2	85.8	84.6	83.3	82.3	82 2
TDAYTANK	°F	91.1	91.4	91.7	91.8	91.0	90.3	91.9	92.0	91.7	90.8	90.5	90.0	92.2	91.6	91.3	90.9	90.3	90 0
Pressures																			
POILGALY	psig	37.8	37.1	37.2	36.9	36.4	35.6	27.2	27.0	27.6	25.6	27.5	24.5	16.5	15.7	15.2	17.4	15.4	15 9
PFUEL	psig	4.7	4.9	5.0	5.3	5.6	5.8	5.3	5.4	5.6	5.8	5.9	6.0	5.7	6.0	6.0	6.1	6.1	6 2
PAMBIENT	psia	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2
PINTBC	psia	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2
PINTAC	psig	10.0	9.0	7.8	6.0	4.3	3.0	7.6	5.4	3 8	2.8	1.9	1.3	2.5	1.6	1.1	0.8	0.6	0.4
PINT_RST	psig	0.06	0.06	0.06	0.05	0 04	0.04	0.03	0.02	0.02	0.02	0.02	0 01	0.0	0.0	0.0	0.0	0.0	0 0
PEXHAT	psig	0.14	0.13	0.11	0.10	0 08	0.07	0.09	0.07	0.06	0.05	0.04	0 04	0.0	0.0	0.0	0.0	0.0	0 0
PCOOL	psig	10.3	10.2	9.9	9.8	9.6	9.5	9.9	9.8	9.7	9.6	9.5	9.4	9.7	9.5	9.4	9.3	9.2	9.1

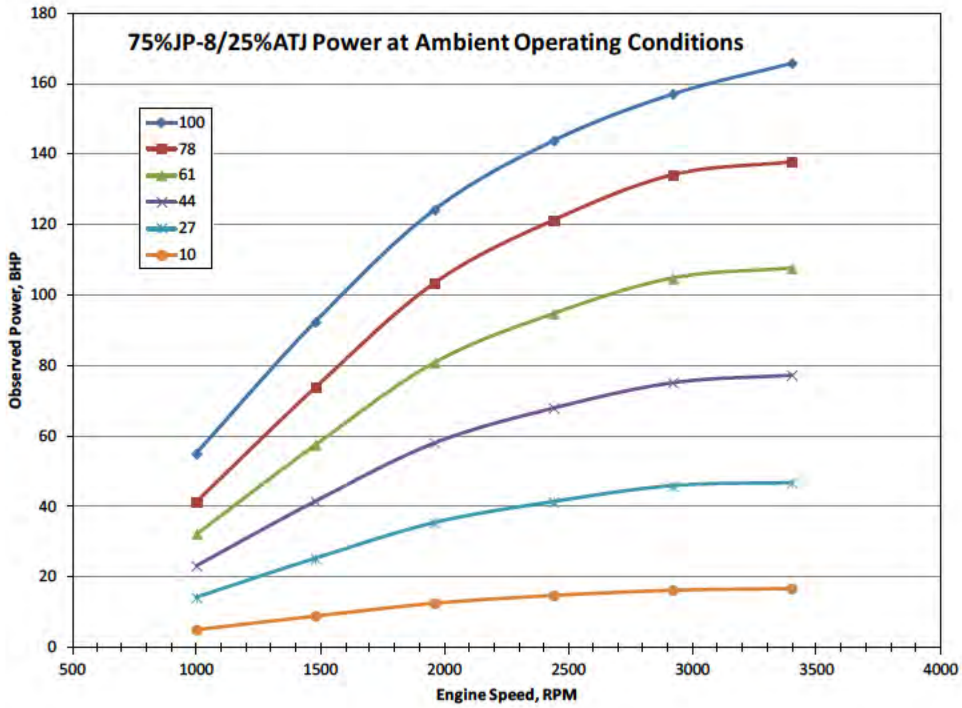

Figure 2. Observed Power with 75%JP-8/25%ATJ at Ambient Operating Conditions

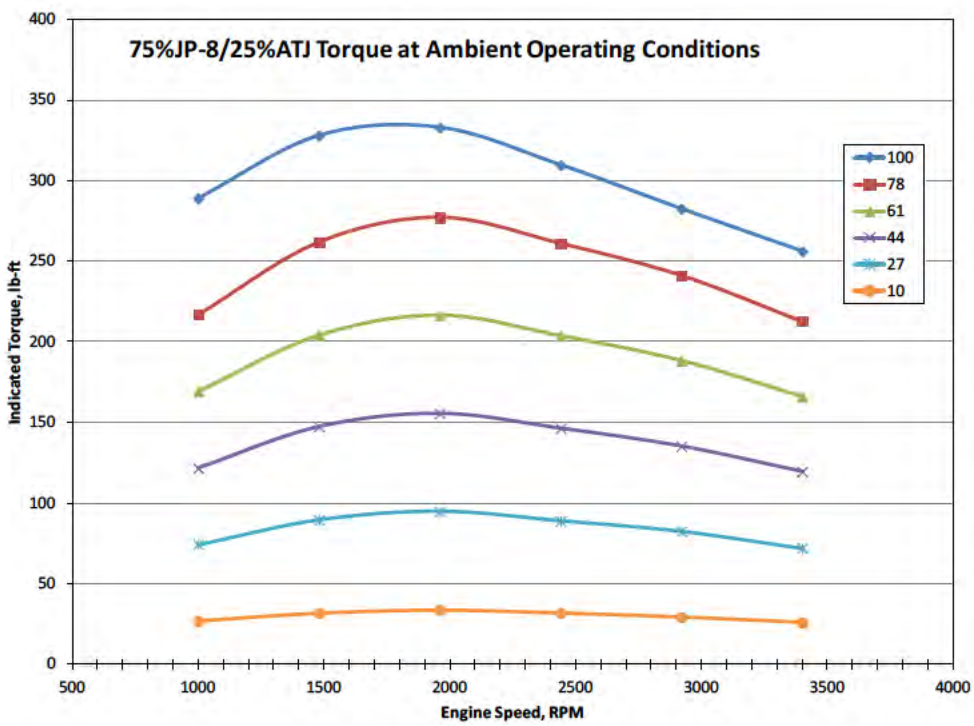

Figure 3. Indicated Torque with 75%JP-8/25%ATJ at Ambient Operating Conditions

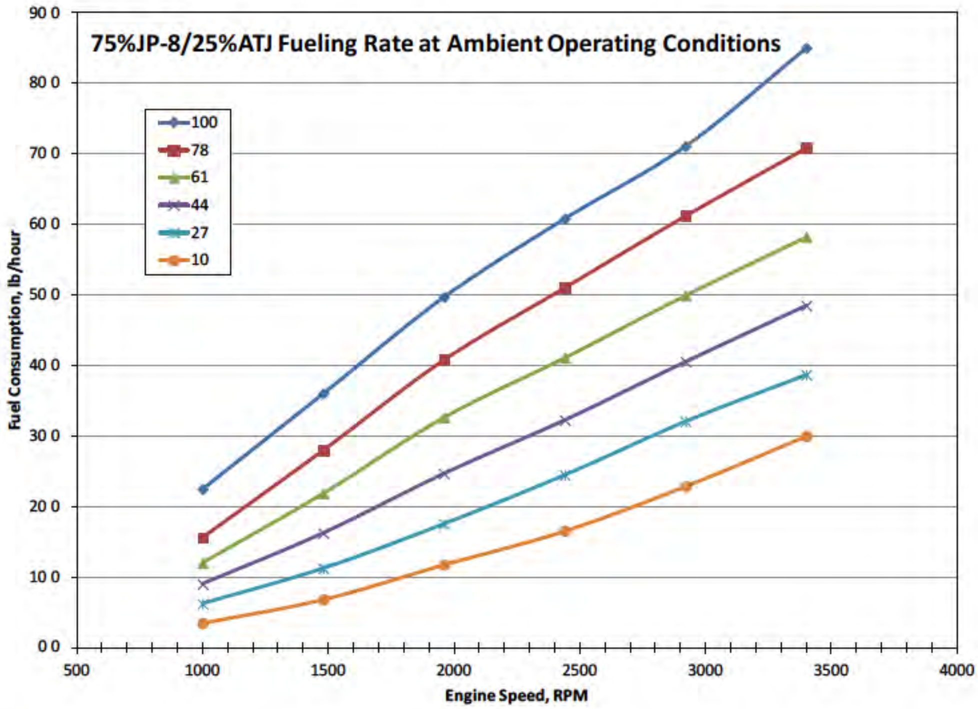

Figure 4. Fueling Rate with 75%JP-8/25%ATJ at Ambient Operating Conditions

The desert temperature operating condition summaries for the JP-8 fuel at the three high engine speeds and three low engine speeds are in Table 12 and Table 13 respectively. The observed engine power for the 36-point speed and load matrix for the JP-8 fuel is shown in Figure 11 for the desert operating conditions. Slightly higher full-load power is seen with JP-8 fuel than the JP-8/ATJ blend because of the marginally higher fuel density, but less power than the JP-8 at ambient conditions. Figure 12 is the indicated torque for the JP-8 fuel across the speed and load matrix at the desert engine conditions. The corresponding desert condition fueling rates for the JP-8 fuel are shown in Figure 13. Because the partial loads points were performed at a constant set point for both fuels, the fuel delivery measurements reveals the most variations between fuels and thermal operating conditions.

Table 8. Operating Condition Summary for GEP 6.5LT Engine with JP-8 Fuel at Ambient Inlet Conditions and High Engine Speeds

Speed Setpoint	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
Load Setpoint	lb-ft	262.9	212.7	166.0	119.3	72.6	25.9	290.9	241.1	188 2	135.2	82.3	29.4	317.9	261.1	203.8	146 5	89.2	31 8
JP-8 Ambient Engine Performance																			
SPEED	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
TORQUE	lb-ft	262.9	212.4	166.0	119.4	72.6	25.8	290.9	241.1	187 3	135.3	82.3	29.8	317.9	261.3	203.6	146.4	89.0	31 9
POWER	BHP	170.2	137.5	107.5	77.3	47.0	16.7	161.7	134.1	104.1	75.3	45.7	16.5	147.7	121.4	94.6	68 0	41.4	14 8
FFUEL	lb/hr	86.74	70.12	57 98	47.26	37 35	28.45	73.14	60.58	49.15	39.19	30.69	21.41	62.32	50.50	40.52	31.56	23.73	15.48
BSFC	lb/BHP-hr	0.510	0.510	0.539	0.612	0.795	1.712	0.452	0.452	0.472	0.521	0.671	1.299	0.422	0.416	0.428	0.464	0 574	1.051
BMEP	psi	99.9	80.8	63.1	45.4	27.6	9.8	110.6	91.7	71 2	51.5	31.3	11.3	120.9	99.4	77.4	55.7	33.8	12.1
FBLOWBY	cfm	4.46	4.14	4 23	3.74	3.71	3.88	3.91	4.30	3.81	3.55	3.83	3 86	3.85	3.89	3.88	3.76	3.61	3.62
CELL_RH	%	22.5	21.0	20.0	18.9	19.1	18.1	17.8	17.9	17.4	17.6	22.3	24.6	26.8	28.6	29.6	28.1	29.1	29 2
Temperatures																			
TCOOLIN	°F	191.7	193.6	195.2	196.2	197.1	198.1	191.9	193.9	195 0	196.3	197.5	198.5	191.6	193.8	195.3	196 8	197.7	198 9
TCOOLOUT	°F	205.0	205.0	205.1	205.1	205.0	205.2	205.0	205.2	204 9	205.0	205.1	205.1	205.0	205.2	205.1	205 2	204.9	204 8
TOILGALY	°F	179.8	184.2	188.2	191.2	196.1	199.8	184.7	190.3	196.1	199.4	206.6	208.1	192.6	196.6	203.0	205.5	210.9	218 8
TOILSUMP	°F	235.0	235.0	235.0	235.0	234.9	235.0	234.9	235.0	235 0	234.8	235.1	235.3	234.9	235.0	235.0	234.7	233.5	234 3
TDRYBULB	°F	102.6	105.0	106.5	107.1	107.4	107.3	107.4	108.2	108 3	108.3	107.3	106.1	104.6	103.8	103.0	102.1	101.3	100.1
TAIRBCOM	°F	79.0	76.5	77.0	76.8	77.0	77.3	76.9	76.4	77.7	76.8	77.0	76.1	77.5	77.3	76.5	76.6	77.0	77.1
TAIRACOM	°F	176.5	160.3	154.4	152.4	150.5	155.3	169.5	162.1	162.1	161.0	163.0	157.6	179.5	178.7	176.3	170.6	161.1	148 5
TEXHLBCK	°F	1373.4	1169.5	1018.2	885.1	757.9	638.5	1246.9	1086.5	919.4	780.6	656.9	534.1	1171.2	982.5	824.4	682.3	563.2	445.7
TEXHRBCK	°F	1363.8	1179.1	1024.2	885.5	754.0	634.3	1245.5	1073.9	915 2	774.7	642.8	523.7	1170.6	971.0	818.6	671.8	550.9	438 2
TFUELHTR	°F	81.2	83.4	82.2	83.2	83.5	83.5	82.0	82.8	83 0	83.0	83.9	83.6	83.2	84.0	84.0	84.5	84.5	84.6
TFUELIN	°F	86.8	86.4	85.5	86.2	85.8	86.1	86.1	86.0	85 8	86.2	85.8	85.9	86.1	85.9	85.9	86.1	85.8	86 0
TFUELOUT	°F	122.6	122.4	121.7	121.9	122.1	122.3	119.1	118.7	118 8	118.9	118.7	119.0	115.0	115.1	115.1	115.3	115.4	115 9
TEXHAT	°F	520.3	493.8	444.1	412.5	365.1	319.1	464.6	473.1	423.4	376.1	321.1	271.7	431.2	422.5	373.0	317.1	272.6	228 9
TEXHCYL1	°F	1312.8	1171.7	1038.2	912.1	789.0	667.5	1189.1	1058.2	918.1	798.0	677.2	552.1	1083.0	935.0	806.1	671.5	563.9	444.1
TEXHCYL2	°F	1334.9	1127.1	996.1	884.1	768.9	660.8	1199.6	1021.3	880.6	758.5	652.2	546.1	1117.4	923.6	789.8	664.4	549.3	454.1
TEXHCYL3	°F	1311.4	1154.4	1010.1	880.2	757.0	644.0	1196.3	1044.4	904.7	780.7	659.8	536.3	1130.3	956.6	825.6	686.8	569.8	455.4
TEXHCYL4	°F	1378.2	1189.8	1041.1	907.0	781.9	662.3	1229.9	1082.7	935 8	801.5	679.8	561.6	1134.4	957.9	812.6	679.2	570.6	461.1
TEXHCYL5	°F	1298.2	1097.6	960.3	841.4	730.3	619.1	1192.9	1006.6	863.1	739.7	626.6	515.4	1109.0	908.0	768.5	644.3	533.3	422.4
TEXHCYL6	°F	1319.0	1118.9	976.8	863.0	743.4	632.2	1186.5	1035.6	881 3	752.0	634.6	525.4	1111.1	934.1	792.6	659.8	546.8	434.1
TEXHCYL7	°F	1273.9	1112.1	971.3	848.9	730.1	623.8	1152.4	1002.7	863.1	733.9	614.0	510.0	1075.2	893.7	757.7	637.1	529.7	429.4
TEXHCYL8	°F	1307.2	1125.2	983.8	853.1	734.9	626.1	1190.1	1050.1	889 2	760.9	644.5	523.1	1109.5	948.0	800.3	672.5	557.5	438.1
TDYNOIN	°F	83.5	83.7	83.1	83.0	82.8	82.5	82.8	83.0	82 8	82.7	83.2	83.6	84.4	84.8	84.9	84.5	84.3	83 8
TDYNOOUT	°F	103.6	100.3	96.5	92.8	89.0	84.9	102.0	99.4	96 0	92.4	89.2	85.9	102.4	100.0	97.0	93.3	89.8	85 8
TDAYTANK	°F	94.6	95.9	96.2	96.1	96.4	95.3	97.7	97.3	97.1	96.7	95.8	93.9	95.6	94.6	94.1	93.4	92.1	91 2
Pressures																			
POILGALY	psig	47.5	46.6	45.6	44.9	44.0	43.4	44.4	43.8	43 2	43.0	42.4	42.3	41.5	40.7	39.9	39.7	39.3	39 0
PFUEL	psig	3.9	4.2	4.5	4.8	5.0	5.2	4.1	4.3	4.6	4.9	5.1	5.3	4.2	4.4	4.7	5.0	5.2	5.4
PAMBIENT	psia	14.3	14.3	14.3	14.3	14.3	14.3	14.2	14.2	14 2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2
PINTBC	psia	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.2	14.1	14.1	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2
PINTAC	psig	5.8	4.6	4.0	3.9	3.7	4.1	6.2	5.5	5.4	5.3	5.5	5.1	7.7	7.7	7.5	6.9	6.0	4 8
PINT_RST	psig	0.13	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0 09	0.08	0 08	0.08	0.08	0.07	0.07
PEXHAT	psig	0.27	0.23	0.21	0.15	0.13	0.12	0.24	0.19	0.15	0.13	0.12	0.11	0.16	0.13	0.11	0.11	0.10	0.08
PCOOL	psig	9.9	10.0	9.8	9.7	9.5	9.4	9.9	9.7	9 5	9.3	9.1	8.9	9.5	9.2	9.1	8.9	8.7	8 5

Table 9. Operating Condition Summary for GEP 6.5LT Engine with JP-8 Fuel at Ambient Inlet Conditions and Low Engine Speeds

Speed Setpoint	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
Load Setpoint	lb-ft	339.9	277.2	216.4	155.5	94.6	33.8	334.3	262.0	204 5	147.0	89.5	32.0	295.4	216.8	169.2	121.6	74.0	26.4
JP-8 Ambient Engine Performance																			
SPEED	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	999	1000	1000	1000
TORQUE	lb-ft	339.9	277.6	216.7	155.2	94.8	33.7	334.3	262.3	204 5	147.0	89.2	32.1	295.4	216.8	169.5	121.7	73.8	26.4
POWER	BHP	126.8	103.6	80.9	57.9	35.4	12.6	94.2	73.9	57.6	41.4	25.2	9.1	56.3	41.3	32.3	23 2	14.1	5 0
FFUEL	lb/hr	50.73	40.63	32 29	24.30	16 93	11.02	36.75	27.96	21.60	15.94	11.07	6 58	23.03	15.65	11.92	9.01	6.23	3.65
BSFC	lb/BHP-hr	0.400	0.392	0.399	0.420	0.479	0.880	0.390	0 378	0.375	0.385	0.440	0.729	0.409	0.379	0.370	0.389	0.444	0.753
BMEP	psi	129.2	105.6	82.4	59.0	36.0	12.8	127.1	99.7	77 8	55.9	33.9	12.2	112.3	82.4	64.4	46 3	28.1	10 0
FBLOWBY	cfm	3.67	3.64	3.65	3.55	3 37	3.34	3.59	3.47	3.42	3.36	3.30	3.18	3.54	3.39	3.30	3.22	3.17	3.19
CELL_RH	%	30.1	28.6	28.3	28.9	29.8	27.7	28.6	28.5	27 3	28.2	28.0	28.6	28.6	29.5	29.3	29.6	31.0	31.7
Temperatures																			
TCOOLIN	°F	190.8	193.6	195.5	197.0	198.7	199.3	190.2	193.8	196 0	197.4	199.1	200.1	189.2	193.8	195.9	197.4	199.0	200.7
TCOOLOUT	°F	204.7	205.2	205.4	205.2	205.2	204.6	204.6	205.2	205.4	205.2	205.3	205.1	205.1	205.1	204.9	205 3	205.2	205 2
TOILGALY	°F	197.1	201.4	205.2	208.8	218.2	218.5	201.2	208.0	218 5	226.2	212.5	230.0	205.5	224.2	225.6	231.3	221.4	216 9
TOILSUMP	°F	235.0	235.3	235.0	234.1	233.1	232.4	233.8	232.9	231 2	232.8	231.0	234.0	234.8	231.3	231.4	235.7	227.1	221 8
TDRYBULB	°F	99.5	99.4	99.1	98.9	98.4	97.8	97.6	97.8	97 9	98.0	97.6	97.1	96.7	96.7	96.6	96 3	95.7	95 2
TAIRBCOM	°F	77.7	76.6	76.5	77.1	77.0	76.9	77.0	76.9	76 9	77.2	76.9	76.7	77.0	77.1	76.8	76.6	77.5	77.7
TAIRACOM	°F	200.8	187.6	175.5	157.8	139.1	123.7	178.5	150.9	132 2	120.0	110.7	103.5	123.4	108.2	102.2	98.7	95.9	93.4
TEXHLBCK	°F	1057.8	895.1	764.3	619.2	487.3	369.9	1006.0	826.2	669 0	531.1	408.8	300.1	982.7	693.8	543.0	431.4	337.6	251.7
TEXHRBCK	°F	1068.2	892.3	749.3	606.0	480.5	368.8	999.6	820.0	660.4	519.3	397.2	290.7	975.7	684.0	527.8	414.8	323.9	242 9
TFUELHTR	°F	84.3	84.4	84.5	84.6	84.8	84.6	84.9	84.9	84 3	84.7	84.7	84.7	85.4	83.8	86.0	84.8	83.3	88.7
TFUELIN	°F	86.1	86.0	86.0	85.9	85.9	86.0	86.3	86.0	85 9	86.1	85.8	86.2	85.9	86.1	85.6	86.7	85.3	86 0
TFUELOUT	°F	111.8	112.4	113.2	113.7	113.9	114.2	113.2	113.2	113.7	113.6	113.8	113.9	113.4	115.0	114.2	113.9	113.8	112 8
TEXHAT	°F	391.7	381.9	336.2	290.7	243.5	204.2	332.1	336.6	294.7	252.7	215.8	180.3	319.4	309.2	257.5	214.7	184.1	158.4
TEXHCYL1	°F	949.7	817.6	702.7	583.2	469.7	369.2	883.3	740.3	608.1	486.3	387.2	288.0	833.8	620.2	487.9	393.9	312.3	239.4
TEXHCYL2	°F	999.7	841.2	728.6	600.4	470.6	362.7	918.1	768.7	624 2	502.3	394.9	296.5	860.9	625.4	504.8	409.1	326.2	247 5
TEXHCYL3	°F	1021.6	876.7	750.6	621.2	495.2	383.9	942.6	810.1	659.7	530.6	418.7	307.7	902.0	681.0	538.7	431.5	342.3	260 9
TEXHCYL4	°F	1000.5	851.9	733.3	613.9	493.3	381.3	929.9	781.3	645.4	525.3	414.2	310.0	879.7	646.0	520.7	421.9	334.6	252 2
TEXHCYL5	°F	1002.3	829.9	702.8	582.0	465.9	356.3	919.1	752.1	616 0	494.6	384.8	285.3	867.0	621.7	502.6	403.5	318.0	245 2
TEXHCYL6	°F	996.9	843.2	722.2	595.0	469.5	356.7	932.1	760.8	624 5	506.5	392.3	291.7	881.8	622.8	504.3	409.1	324.1	245 9
TEXHCYL7	°F	984.9	825.0	693.3	568.0	459.9	356.7	897.0	728.1	600.1	482.0	368.9	277.5	850.8	594.7	470.1	376.1	299.2	229 2
TEXHCYL8	°F	996.0	855.7	739.7	598.4	478.9	365.8	923.3	763.1	628 0	508.8	395.4	291.7	892.3	652.0	516.7	416.9	328.1	250 2
TDYNOIN	°F	83.9	83.8	83.7	83.4	83.2	83.1	83.4	83.6	83.4	83.4	83.1	82.6	82.8	82.9	82.8	82.3	82.2	82 0
TDYNOOUT	°F	99.4	96.8	93.9	90.9	87.8	84.8	94.7	92.7	90.6	88.5	86.3	83.8	89.5	88.0	86.8	85.2	83.9	82.6
TDAYTANK	°F	92.3	92.6	92.4	91.4	90.1	89.3	90.9	91.4	91 2	90.2	89.4	88.7	89.5	89.1	88.9	88.5	87.8	87 2
Pressures																			
POILGALY	psig	37.8	37.3	36.9	36.9	36.2	36.6	28.2	27.4	26.4	25.5	27.4	25.1	16.5	15.5	15.4	14.8	16.1	16 9
PFUEL	psig	4.4	4.6	4.8	5.2	5.4	5.5	5.2	5.3	5.4	5.6	5.8	5.8	5.5	5.8	5.9	5.9	6.0	6 0
PAMBIENT	psia	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3
PINTBC	psia	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3
PINTAC	psig	10.1	9.0	7.8	6.1	4.3	2.9	7.7	5.4	3 9	2.8	1.9	1.4	2.7	1.6	1.2	0.9	0.7	0 5
PINT_RST	psig	0.06	0.06	0.06	0.05	0 04	0.04	0.03	0.02	0.02	0.02	0.02	0 02	0.0	0.0	0.0	0.0	0.0	0 0
PEXHAT	psig	0.11	0.10	0.09	0.07	0 06	0.05	0.07	0.05	0.04	0.04	0.03	0 03	0.0	0.0	0.0	0.0	0.0	0 0
PCOOL	psig	9.0	8.6	8.6	8.4	8.2	8.2	8.5	8.4	8.4	8.3	8.1	8.0	8.4	8.2	8.1	8.0	7.9	7.7

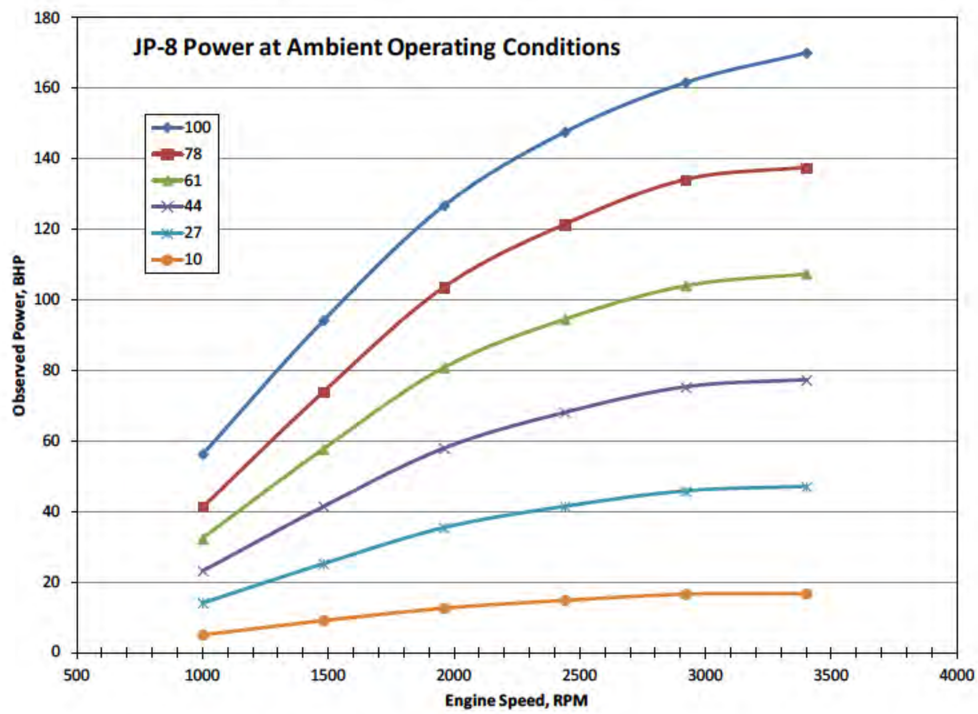

Figure 5. Observed Power with JP-8 at Ambient Operating Conditions

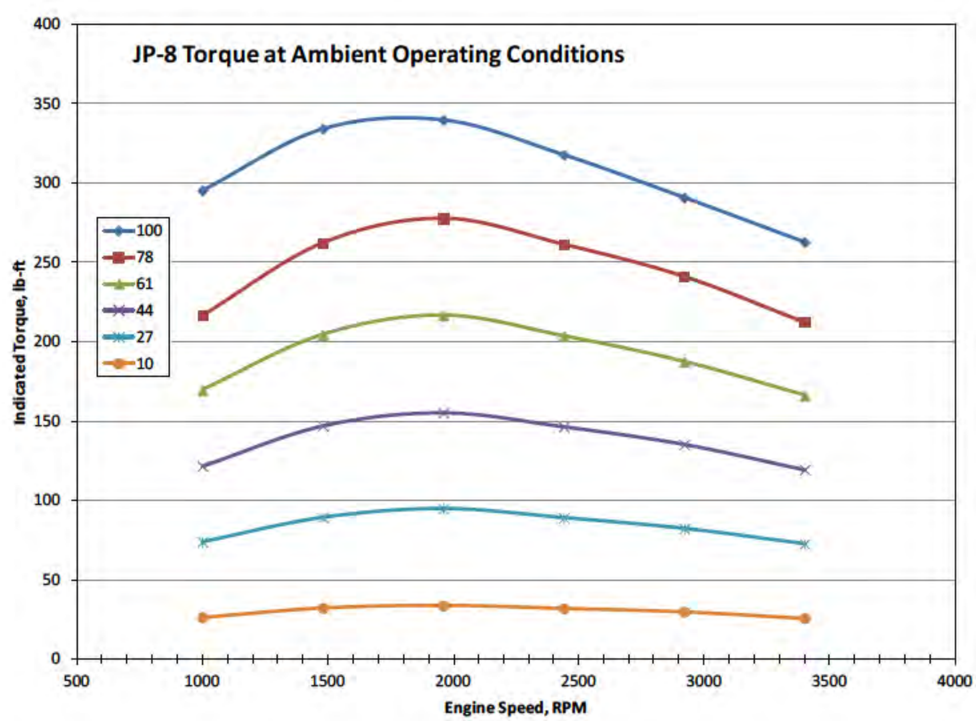

Figure 6. Indicated Torque with JP-8 at Ambient Operating Conditions

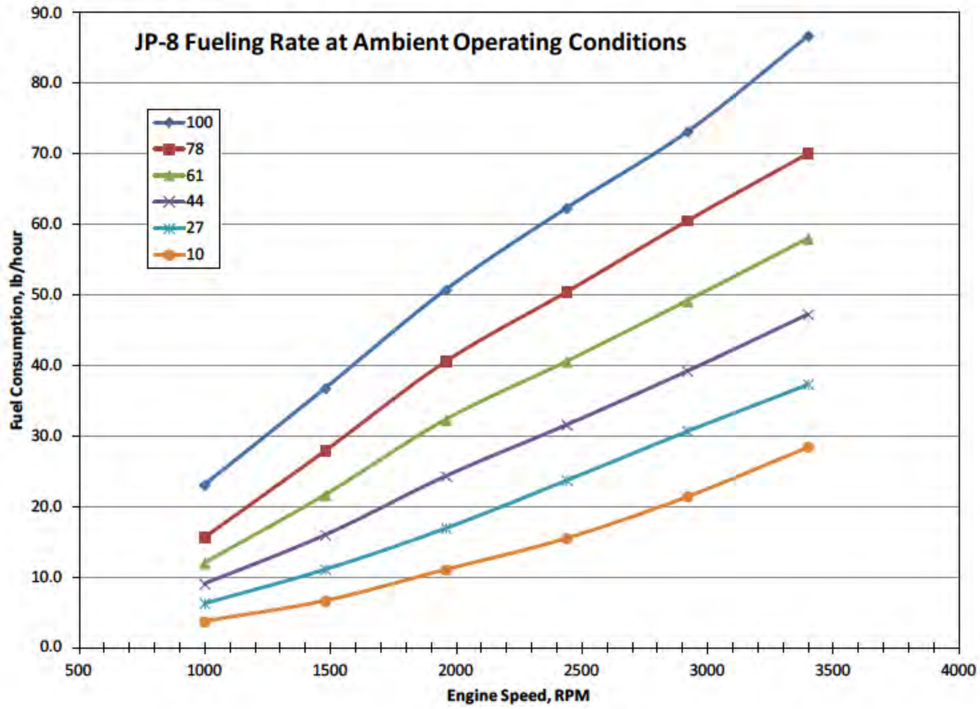

Figure 7. Fueling Rate with JP-8 at Ambient Operating Conditions

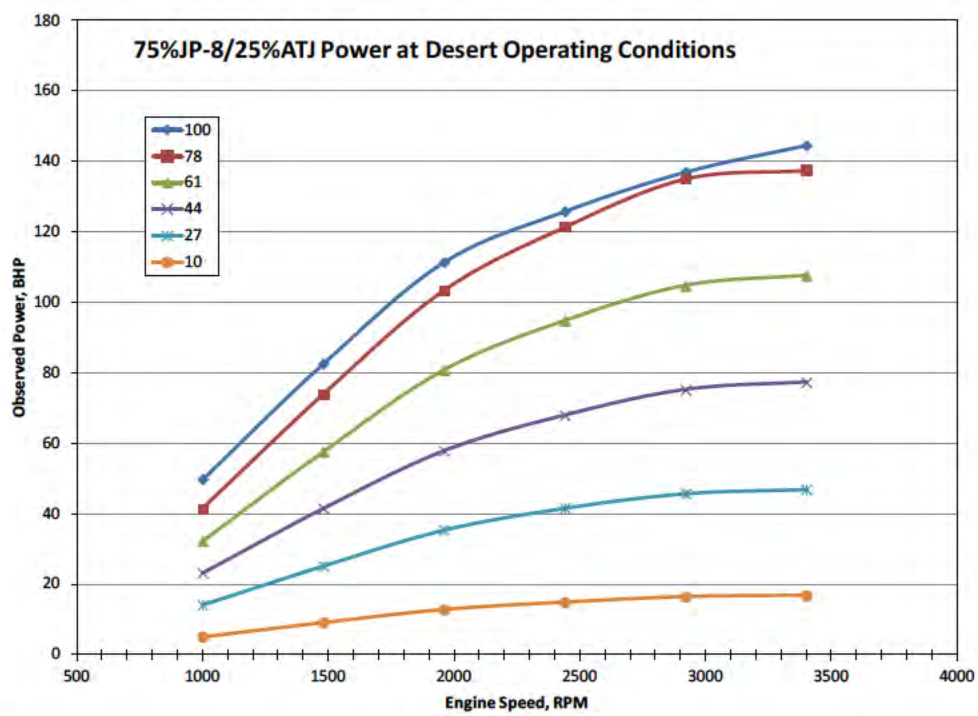

Figure 8. Observed Power with 75%JP-8/25%ATJ at Desert Operating Conditions

Table 10. Operating Condition Summary for GEP 6.5LT Engine with JP-8/ATJ Fuel Blend at Desert Inlet Conditions and High Engine Speeds

Speed Setpoint	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
Load Setpoint	lb-ft	223.3	212.7	166.0	119.3	72.6	25.9	246.3	241.1	188 2	135.2	82.3	29.4	270.8	261.1	203.8	146 5	89.2	31 8
75% JP-8/25% ATJ Desert Engine Performance																			
SPEED	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
TORQUE	lb-ft	223.3	212.4	166.1	119.3	72.3	25.8	246.3	243.0	188 3	135.1	82.1	29.3	270.8	261.2	203.9	146.1	89.4	31 8
POWER	BHP	144.5	137.5	107.5	77.2	46.8	16.7	136.9	135.1	104.7	75.1	45.6	16.3	125.8	121.4	94.7	67 9	41.5	14 8
FFUEL	lb/hr	80.21	75.86	60 97	49.93	40 06	30.31	66.41	65.87	51.94	41.00	31.70	22.63	56.31	53.80	43.02	33.39	24.35	16.70
BSFC	lb/BHP-hr	0.555	0.552	0.567	0.647	0.856	1.824	0.485	0.488	0.496	0.546	0.695	1.392	0.448	0.443	0.454	0.492	0 587	1.137
BMEP	psi	84.9	80.7	63.1	45.4	27.5	9.8	93.6	92.4	71.6	51.4	31.2	11.2	102.9	99.3	77.5	55 5	34.0	12.1
FBLOWBY	cfm	4.38	4.12	3 98	3.61	4 30	3.51	4.01	3.88	3.69	3.87	3.62	3 58	3.22	3.70	3.83	3.73	3.72	3.68
CELL_RH	%	26.2	22.7	20.5	19.3	20.1	19.6	17.9	17.3	17.7	17.4	16.7	17.5	38.1	31.8	30.8	30 2	28.1	28 9
Temperatures																			
TCOOLIN	°F	205.0	205.5	207.3	208.5	209.7	210.5	205.4	205.3	207.4	208.9	209.9	211.0	205.4	206.2	207.7	209 3	210.6	211 9
TCOOLOUT	°F	218.0	218.0	218.0	218.0	218.1	217.9	218.0	217.8	217 9	218.1	217.9	217.9	217.9	218.2	217.8	218 0	217.8	217 8
TOILGALY	°F	172.4	173.1	179.6	188.1	189.1	192.9	182.0	181.7	187 9	191.2	195.3	202.0	188.7	191.4	197.6	201.4	206.0	208.7
TOILSUMP	°F	235.2	234.3	235.0	235.0	235.1	234.9	235.0	234.7	235.1	234.8	235.1	235.5	234.9	234.9	234.8	235.2	235.2	233 8
TDRYBULB	°F	103.2	106.6	109.1	110.8	111.1	110.8	111.2	112.1	113.1	113.3	113.0	112.8	93.2	96.0	97.1	97 5	97.9	97 9
TAIRBCOM	°F	120.1	120.0	120.2	120.0	120.1	120.6	119.6	120.4	120.1	120.3	120.2	119.5	120.3	120.5	119.9	120.3	120.0	120 0
TAIRACOM	°F	214.4	210.1	201.5	197.7	197.9	200.0	213.4	213.4	206 8	210.1	210.1	204.3	226.6	225.3	222.7	217.2	204.1	189.6
TEXHLBCK	°F	1399.5	1342.9	1140.4	991.2	867.0	726.1	1250.6	1256.5	1047 0	875.4	734.4	599.5	1139.6	1097.1	918.7	765.9	617.6	499 2
TEXHRBCK	°F	1395.5	1346.5	1149.7	998.6	859.1	719.0	1248.9	1246.3	1038 9	867.5	723.0	588.3	1131.0	1094.1	909.3	751.2	611.4	487 3
TFUELHTR	°F	153.1	153.1	150.9	150.5	149.8	149.3	151.0	151.9	148.4	148.1	148.3	147.9	156.7	152.0	147.9	150.6	148.2	148.6
TFUELIN	°F	144.5	144.7	144.4	144.2	144.5	144.6	145.3	144.6	144.1	144.7	144.6	144.3	146.8	143.4	144.8	145.0	144.2	144.7
TFUELOUT	°F	160.7	160.8	161.0	160.3	160.2	160.4	158.1	158.0	158.1	157.8	157.9	157.9	153.2	151.2	152.0	151.5	151.7	151.6
TEXHAT	°F	537.5	538.8	477.9	444.5	401.7	352.8	483.1	500.6	459 2	401.3	353.6	299.8	504.7	469.5	400.1	341.1	283.4	239 5
TEXHCYL1	°F	1332.2	1311.1	1149.0	1017.2	894.4	763.3	1185.1	1205.6	1033 2	877.4	749.7	613.4	1055.3	1036.1	878.4	741.9	611.0	504.7
TEXHCYL2	°F	1352.1	1282.9	1095.6	963.0	864.2	739.0	1212.2	1191.5	1007 2	845.8	721.8	605.8	1090.7	1041.1	874.4	736.3	610.8	478 8
TEXHCYL3	°F	1347.6	1303.8	1127.1	994.7	870.6	736.8	1211.8	1222.5	1028.4	880.6	740.8	604.0	1100.0	1079.8	911.8	770.4	636.3	501.7
TEXHCYL4	°F	1399.7	1360.7	1171.7	1015.2	891.4	758.0	1241.5	1246.8	1050 8	894.1	756.0	627.2	1111.6	1070.3	909.1	766.2	624.6	508.7
TEXHCYL5	°F	1321.8	1259.9	1077.9	945.7	826.7	696.4	1186.7	1161.5	972 0	828.3	697.8	576.8	1074.1	1020.7	858.0	717.7	591.5	473 0
TEXHCYL6	°F	1346.8	1291.6	1093.3	960.1	847.9	715.8	1197.0	1205.8	1005 2	845.6	715.3	588.3	1086.1	1046.1	879.2	738.3	599.9	487.4
TEXHCYL7	°F	1305.7	1261.1	1080.6	942.6	814.8	694.1	1160.2	1153.0	969 8	813.5	690.3	568.2	1048.1	1010.2	841.8	704.4	586.3	467.4
TEXHCYL8	°F	1332.3	1278.9	1096.2	958.3	836.3	702.1	1183.7	1195.1	1005 3	848.8	713.2	582.5	1086.9	1050.8	889.9	750.2	605.9	498.4
TDYNOIN	°F	83.7	83.9	84.0	84.0	84.0	83.8	84.4	84.2	84.4	83.8	83.7	83.5	84.3	84.4	84.4	84.3	83.9	83.7
TDYNOOUT	°F	101.0	100.5	97.3	93.8	90.2	86.2	100.8	100.8	97 5	93.5	89.8	85.9	99.2	98.8	95.7	92.5	88.9	85.6
TDAYTANK	°F	98.7	100.1	100.2	100.2	99.9	99.1	99.1	100.3	100.7	100.1	99.7	99.5	92.1	92.6	93.1	93.3	93.7	93.4
Pressures																			
POILGALY	psig	47.2	47.3	46.0	45.2	44.5	43.6	44.3	44.4	43 8	43.3	43.1	42.7	41.7	41.5	40.3	39.8	39.6	39.7
PFUEL	psig	3.8	3.8	4.1	4.3	4.4	4.7	4.0	4.1	4 3	4.5	4.7	5.0	4.3	4.3	4.5	4.6	5.0	5 2
PAMBIENT	psia	14.3	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2	14.2	14.2	14.2	14.3	14.3	14.3	14.3	14.3	14 3
PINTBC	psia	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.2	14.2	14.2	14.2	14.2	14 2
PINTAC	psig	5.2	4.8	4.1	3.8	3.8	3.9	5.9	5.8	5 2	5.5	5.4	5.0	7.7	7.7	7.5	6.9	5.7	4 5
PINT_RST	psig	0.12	0.12	0.11	0.11	0.11	0.11	0.10	0.09	0.09	0.09	0.09	0 09	0.08	0 08	0.08	0.08	0.07	0.07
PEXHAT	psig	0.27	0.27	0.24	0.19	0.17	0.16	0.25	0.25	0.20	0.17	0.17	0.16	0.12	0.12	0.10	0.09	0.09	0.07
PCOOL	psig	12.7	13.1	12.8	12.7	12.5	12.3	12.8	12.8	12.6	12.4	12.2	11.9	10.6	11.4	11.5	11.5	11.4	11.1

Table 11. Operating Condition Summary for GEP 6.5LT Engine with JP-8/ATJ Fuel Blend at Desert Inlet Conditions and Low Engine Speeds

Speed Setpoint	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
Load Setpoint	lb-ft	298.4	277.2	216.4	155.5	94.6	33.8	292.9	262	204 5	147.0	89.5	32.0	261.1	216.8	169.2	121.6	74.0	26.4
75% JP-8/25% ATJ Desert Engine Performance																			
SPEED	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
TORQUE	lb-ft	298.4	277.1	216.4	154.7	94.7	34.0	292.9	262.0	204.4	147.0	89.2	32.1	261.1	216.9	169.2	121.7	74.0	26.4
POWER	BHP	111.4	103.4	80.7	57.8	35.3	12.7	82.6	73.8	57.6	41.4	25.1	9.0	49.7	41.3	32.2	23 2	14.1	5 0
FFUEL	lb/hr	46.23	42.58	33.77	25.30	17.72	11.83	33.15	29.46	22.42	16.61	11.40	6 88	20.67	16.21	12.31	9.12	6.25	3.50
BSFC	lb/BHP-hr	0.415	0.412	0.418	0.438	0.502	0.935	0.402	0 399	0.389	0.401	0.454	0.764	0.416	0.392	0.382	0.394	0.445	0.703
BMEP	psi	113.4	105.3	82.3	58.8	36.0	12.9	111.4	99.6	77.7	55.9	33.9	12.2	99.3	82.5	64.3	46 3	28.1	10 0
FBLOWBY	cfm	3.75	3.73	3.69	3.65	3 53	3.45	3.58	3.50	3.48	3.44	3.38	3 33	3.51	3.45	3.45	3.43	3.37	3.31
CELL_RH	%	29.1	28.4	28.4	26.9	27.3	26.8	26.0	25.2	25.4	25.1	24.0	24.7	24.5	24.6	24.0	23.1	24.3	25 3
Temperatures																			
TCOOLIN	°F	204.6	205.8	208.1	210.0	211.5	212.6	204.1	205.6	208.7	210.0	212.1	213.4	204.1	206.7	209.7	210.6	211.1	213 2
TCOOLOUT	°F	217.8	218.2	218.3	218.3	218.1	217.9	217.5	217.8	218 5	217.6	218.4	218.1	218.3	218.5	218.7	217 8	217.5	217 5
TOILGALY	°F	193.3	196.0	201.1	202.7	211.3	213.6	199.1	202.0	206 8	207.0	216.4	224.6	193.2	220.0	207.1	226.4	228.5	220 8
TOILSUMP	°F	235.0	235.0	235.4	234.8	232.6	232.6	233.8	233.0	233.6	230.7	233.7	230.6	231.6	232.1	226.2	232.6	233.8	226 0
TDRYBULB	°F	98.1	98.6	99.2	99.3	99.1	99.2	99.3	99.4	99.6	99.9	100.0	100.0	100.0	100.5	100.4	100.7	100.8	100 9
TAIRBCOM	°F	120.0	120.1	119.6	119.4	120.4	120.5	119.2	120.5	119.6	120.0	121.8	117.5	120.4	123.7	114.4	108.9	110.3	116.6
TAIRACOM	°F	241.0	235.1	219.2	199.4	179.2	164.2	205.7	194.2	173.7	159.5	151.5	141.1	155.4	150.7	137.2	129.8	128.6	130.6
TEXHLBCK	°F	1055.8	997.5	843.7	681.8	542.8	418.6	1008.0	929.7	750.1	586.6	450.5	333.1	948.7	778.3	607.1	463.9	359.9	275 0
TEXHRBCK	°F	1052.2	994.1	836.3	678.1	534.4	415.6	1000.1	920.0	746 9	579.9	439.0	322.1	940.1	769.7	595.1	455.5	352.2	268 3
TFUELHTR	°F	151.5	150.6	150.0	149.5	148.9	148.2	149.3	148.8	149 2	147.9	148.8	148.5	148.1	149.1	149.5	149.4	148.8	149.1
TFUELIN	°F	144.6	144.3	144.7	144.4	144.6	144.4	144.3	144.4	144.7	144.3	144.4	144.4	144.6	144.2	144.4	144.4	144.5	144 2
TFUELOUT	°F	149.8	149.9	150.3	150.1	149.8	149.6	148.8	148.9	148.6	148.4	148.4	148.4	147.6	147.1	147.3	147.0	147.1	146.6
TEXHAT	°F	379.8	402.9	358.7	307.0	258.2	215.5	328.5	355.1	314 3	267.9	227.8	192.9	306.8	318.7	273.7	235.0	202.0	173.4
TEXHCYL1	°F	961.9	928.0	784.1	643.8	518.5	413.7	885.2	829.5	682.6	542.9	422.7	318.4	811.8	694.3	556.9	431.4	336.0	261.7
TEXHCYL2	°F	1004.1	945.4	798.1	657.0	525.6	407.4	925.5	849.0	691 5	554.1	433.9	327.0	826.9	690.3	550.5	431.6	341.7	268.7
TEXHCYL3	°F	1028.8	981.7	841.6	695.3	560.3	441.9	962.7	907.4	757.6	606.4	467.7	341.7	884.5	747.9	607.8	476.2	376.8	293.7
TEXHCYL4	°F	999.5	946.1	813.7	672.3	546.2	428.6	937.2	865.1	717.6	572.4	454.4	343.1	859.4	723.6	583.8	458.7	361.1	282 2
TEXHCYL5	°F	984.8	919.3	782.4	644.2	517.5	403.1	921.2	843.9	698.1	555.8	425.6	313.9	837.6	691.8	558.1	442.4	347.1	268 9
TEXHCYL6	°F	1001.8	945.4	797.7	651.2	527.1	402.7	937.1	864.8	702 0	559.4	437.1	325.2	858.0	707.0	562.5	442.8	349.1	271 3
TEXHCYL7	°F	956.1	902.6	763.3	633.6	503.2	389.2	887.7	807.4	657.4	520.5	403.1	303.5	813.2	671.7	520.8	406.9	319.5	246 0
TEXHCYL8	°F	992.5	945.1	810.9	661.3	529.1	412.7	918.7	856.2	699.1	560.0	431.9	319.2	851.6	711.6	570.9	443.3	344.1	264.4
TDYNOIN	°F	84.3	84.1	84.1	83.5	83.5	83.7	83.4	83.1	83.4	83.5	83.0	82.7	83.0	83.3	82.7	82.7	82.8	82 3
TDYNOOUT	°F	97.2	96.2	93.7	90.5	87.7	85.2	92.9	91.8	90 2	88.4	86.0	83.8	88.7	88.2	86.5	85.5	84.5	82 9
TDAYTANK	°F	92.9	93.0	93.2	92.9	92.7	93.0	92.1	92.0	92 2	92.6	92.7	92.6	92.4	92.3	91.6	91.7	91.5	91.4
Pressures																			
POILGALY	psig	38.2	37.8	37.2	37.1	36.7	36.6	28.2	27.9	27.1	27.7	26.1	25.8	17.8	15.7	17.5	15.3	15.1	16 2
PFUEL	psig	4.4	4.5	4.6	4.8	5.0	5.2	4.8	4.9	5 2	5.4	5.5	5.6	5.4	5.5	5.7	5.8	5.8	5 8
PAMBIENT	psia	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3
PINTBC	psia	14.2	14.2	14.2	14.2	14.2	14.3	14.3	14.3	14 3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3
PINTAC	psig	9.4	8.9	7.5	5.8	4.0	2.7	6.2	5.2	3.7	2.5	1.7	1.2	2.0	1.5	1.1	0.8	0.6	0.4
PINT_RST	psig	0.06	0.06	0.05	0.05	0 04	0.03	0.03	0.02	0.02	0.02	0.02	0 02	0.0	0.0	0.0	0.0	0.0	0 0
PEXHAT	psig	0.11	0.10	0.09	0.07	0 06	0.05	0.06	0.05	0.04	0.04	0.03	0 03	0.0	0.0	0.0	0.0	0.0	0 0
PCOOL	psig	11.7	11.5	11.3	11.2	11.0	10.9	11.1	11.0	10 9	10.8	10.8	10.5	11.0	10.9	10.8	10.5	10.4	10 0

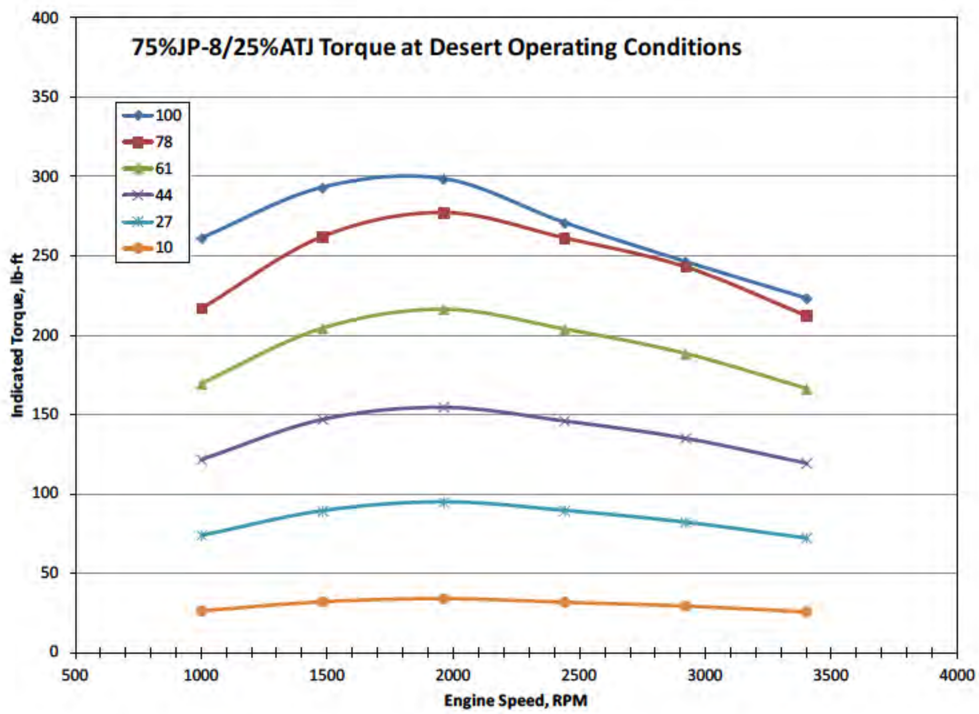

Figure 9. Indicated Torque with 75%JP-8/25%ATJ at Desert Operating Conditions

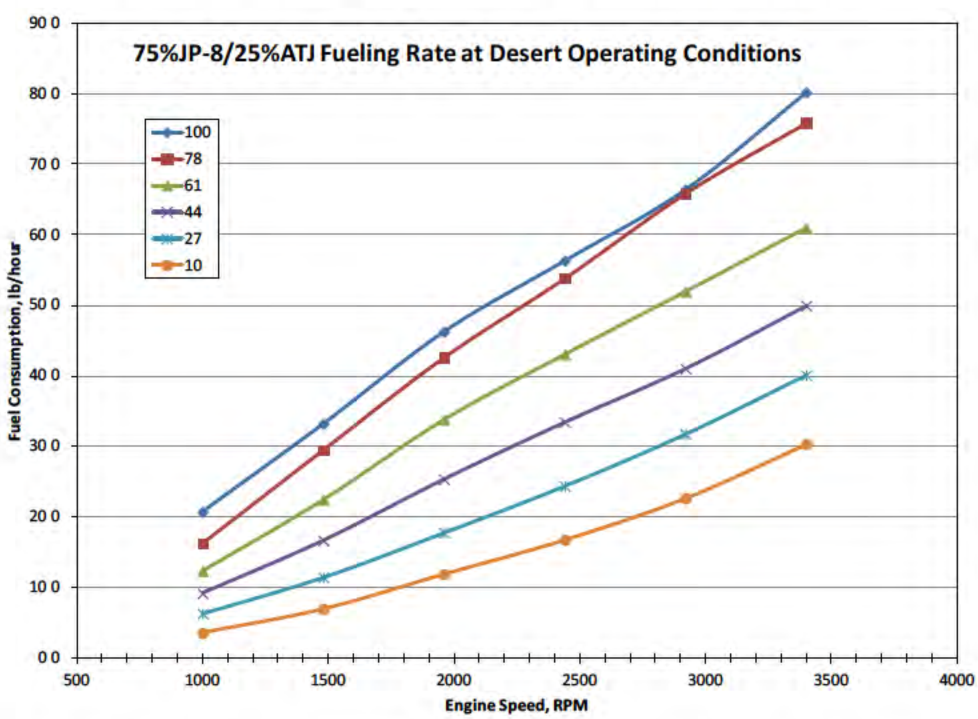

Figure 10. Fueling Rate with 75%JP-8/25%ATJ at Desert Operating Conditions

Table 12. Operating Condition Summary for GEP 6.5LT Engine with JP-8 Fuel at Desert Inlet Conditions and Low Engine Speeds

Speed Setpoint	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
Load Setpoint	lb-ft	244.0	212.7	166.0	119.3	72.6	25.9	267.0	241.1	188 2	135.2	82.3	29.4	291.7	261.1	203.8	146 5	89.2	31 8
JP-8 Desert Engine Performance																			
SPEED	RPM	3400	3400	3400	3400	3400	3400	2920	2920	2920	2920	2920	2920	2440	2440	2440	2440	2440	2440
TORQUE	lb-ft	244.0	212.1	166.1	119.3	72.7	26.0	267.0	241.4	188 5	135.1	82.5	29.6	291.7	260.8	203.7	146.4	88.9	31 8
POWER	BHP	158.0	137.3	107.5	77.2	47.0	16.9	148.5	134.2	104 8	75.1	45.8	16.4	135.6	121.1	94.6	68 0	41.3	14 8
FFUEL	lb/hr	84.63	74.32	61.11	49.28	39 29	29.56	71.01	64.81	51.95	41.27	32.01	22 53	59.72	53.84	42.84	33.08	24.81	16.25
BSFC	lb/BHP-hr	0.536	0.541	0.569	0.638	0.836	1.761	0.478	0.483	0.496	0.550	0.699	1.375	0.441	0.444	0.453	0.486	0.603	1.102
BMEP	psi	92.8	80.6	63.1	45.4	27.6	9.9	101.5	91.8	71.7	51.4	31.4	11.2	110.9	99.1	77.4	55.7	33.8	12.1
FBLOWBY	cfm	3.74	3.82	3 82	3.71	3.61	3.80	3.72	3.64	3.76	3.69	3.73	3.68	3.85	3.88	3.80	3.74	3.65	3.54
CELL_RH	%	29.7	28.6	28.4	27.9	28.5	28.8	28.1	27.3	27.7	26.6	26.9	26.4	29.7	31.2	31.4	31.1	32.1	32.4
Temperatures																			
TCOOLIN	°F	204.5	206.2	207.7	208.9	210.0	211.1	205.2	206.0	207 8	209.0	210.4	211.3	205.3	206.2	208.0	209.7	211.0	212 2
TCOOLOUT	°F	217.8	218.1	218.0	217.9	218.0	218.1	218.0	217.9	217 9	217.7	218.0	217.7	218.2	218.0	217.9	218 2	218.1	217 9
TOILGALY	°F	171.2	177.9	182.6	186.9	190.1	193.0	175.2	182.8	187.7	191.9	196.4	203.7	186.6	189.6	193.7	201.3	207.1	210.4
TOILSUMP	°F	235.7	235.0	235.0	235.0	235.0	235.0	235.1	235.0	235 0	235.0	235.0	234.8	235.1	235.0	235.0	234.9	235.0	234 9
TDRYBULB	°F	84.8	86.8	87.9	88.6	88.6	88.6	88.5	89.6	89 9	89.7	89.5	89.2	88.6	88.2	88.3	87.7	86.9	86 3
TAIRBCOM	°F	120.0	120.1	119.8	120.2	120.4	119.5	120.3	119.9	119 9	120.5	120.0	119.8	119.7	120.1	120.0	120.0	120.1	120 0
TAIRACOM	°F	216.7	207.0	198.6	197.2	195.8	199.8	215.6	210.2	208 3	210.8	209.6	202.5	226.6	226.7	222.7	215.3	203.6	187 8
TEXHLBCK	°F	1428.0	1294.8	1119.2	961.8	820.9	682.7	1284.8	1206.7	1008 9	847.9	718.0	581.4	1182.1	1078.7	905.7	758.5	621.4	493 3
TEXHRBCK	°F	1422.8	1299.4	1123.6	965.7	826.1	684.4	1287.0	1193.0	999 8	842.7	702.5	568.3	1181.5	1070.0	895.7	733.4	602.3	468 5
TFUELHTR	°F	93.1	101.4	71.0	64.1	62.5	61.7	100.4	89.4	75 8	73.8	78.4	76.3	108.1	95.3	87.0	95.2	94.0	90 2
TFUELIN	°F	139.1	148.3	147.7	146.7	146.3	146.3	142.0	147.2	145.6	145.2	145.5	145.3	141.8	147.0	144.1	146.4	145.0	146 2
TFUELOUT	°F	134.4	138.0	141.1	137.6	137.9	139.1	132.1	139.3	135.7	134.9	136.6	139.5	130.5	137.8	133.4	134.7	136.8	138.6
TEXHAT	°F	511.9	494.7	448.3	414.1	364.1	314.8	458.5	481.7	422 3	369.2	313.5	266.9	419.5	428.7	375.9	323.5	277.2	230.4
TEXHCYL1	°F	1363.6	1286.0	1119.4	974.1	848.5	711.2	1223.8	1163.3	1003 8	860.9	735.4	598.7	1095.2	1014.9	866.6	725.0	607.6	476.6
TEXHCYL2	°F	1380.6	1229.9	1073.4	939.3	825.1	706.7	1233.0	1139.4	967 2	814.3	698.1	588.8	1127.3	1010.6	856.9	728.0	603.3	489.1
TEXHCYL3	°F	1366.7	1267.2	1105.3	963.1	832.0	698.0	1241.2	1159.4	987.7	851.1	717.4	584.6	1148.3	1050.2	893.2	751.6	622.0	485.7
TEXHCYL4	°F	1424.0	1309.3	1145.2	985.4	849.0	710.6	1264.4	1199.4	1023 8	868.5	743.4	611.0	1145.8	1050.5	896.2	754.9	627.9	494 0
TEXHCYL5	°F	1350.9	1202.9	1051.6	915.5	796.3	668.4	1224.3	1117.4	941 8	799.4	678.9	558.7	1121.1	998.0	845.8	706.3	585.6	451 8
TEXHCYL6	°F	1368.7	1237.6	1072.6	928.6	802.3	671.2	1225.8	1146.7	960.6	816.7	694.5	566.9	1117.4	1024.7	867.3	728.7	601.6	484 2
TEXHCYL7	°F	1328.7	1219.1	1062.5	923.2	799.6	670.6	1194.1	1110.0	936.7	799.3	674.8	548.0	1084.4	990.6	833.5	689.9	578.1	455 8
TEXHCYL8	°F	1358.9	1243.5	1079.3	934.2	794.2	666.4	1224.3	1159.7	974.1	825.9	704.3	569.9	1126.1	1037.6	876.0	746.4	613.4	489.6
TDYNOIN	°F	74.9	75.2	75.4	75.4	75.2	75.0	75.3	75.5	75.4	75.2	74.9	74.7	75.0	75.1	75.1	74.9	74.7	74.4
TDYNOOUT	°F	93.7	91.7	88.5	85.0	81.3	77.3	93.1	92.0	88 5	84.8	80.8	76.9	91.4	90.2	87.0	83.6	80.1	76.4
TDAYTANK	°F	84.2	84.5	85.1	84.9	84.6	84.5	84.1	84.7	84.6	84.3	84.0	84.0	83.6	84.0	83.8	83.3	83.0	82 9
Pressures																			
POILGALY	psig	48.0	47.6	47.0	46.6	45.5	44.8	45.0	44.5	44.1	43.8	43.5	43.0	41.8	41.4	40.9	40.2	39.8	39.6
PFUEL	psig	3.8	4.0	4.2	4.5	4.7	5.0	4.0	4.1	4.4	4.6	4.8	5.1	4.2	4.3	4.5	4.7	5.0	5 3
PAMBIENT	psia	14.4	14.4	14.3	14.3	14.3	14.3	14.3	14.3	14 3	14.3	14.3	14.3	14.4	14.4	14.4	14.4	14.4	14.4
PINTBC	psia	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14 2	14.2	14.2	14.3	14.3	14.3	14.3	14.3	14.3	14 3
PINTAC	psig	5.5	4.8	4.1	3.9	3.8	4.2	6.2	5.8	5.6	5.7	5.7	5.1	7.9	7.9	7.5	6.9	5.8	4.4
PINT_RST	psig	0.13	0.12	0.12	0.11	0.11	0.12	0.11	0.10	0.10	0.10	0.10	0.10	0.08	0 08	0.08	0.08	0.07	0.07
PEXHAT	psig	0.29	0.26	0.23	0.16	0.13	0.12	0.24	0.21	0.15	0.13	0.11	0.10	0.16	0.14	0.12	0.10	0.08	0.06
PCOOL	psig	12.1	12.6	12.5	12.3	12.1	11.7	12.5	12.4	12.1	11.7	11.6	11.3	12.0	12.0	11.6	11.3	11.0	10 9

Table 13. Operating Condition Summary for GEP 6.5LT Engine with JP-8 Fuel at Desert Inlet Conditions and Low Engine Speeds

Speed Setpoint	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
Load Setpoint	lb-ft	312.5	277.2	216.4	155.5	94.6	33.8	305.1	262.0	204 5	147.0	89.5	32.0	267.7	216.8	169.2	121.6	74.0	26.4
JP-8 Desert Engine Performance																			
SPEED	RPM	1960	1960	1960	1960	1960	1960	1480	1480	1480	1480	1480	1480	1000	1000	1000	1000	1000	1000
TORQUE	lb-ft	312.5	277.4	216.1	155.5	94.1	34.0	305.1	262.0	204 5	146.9	89.0	32.3	267.7	216.5	169.2	121.4	74.1	26.7
POWER	BHP	116.6	103.5	80.6	58.0	35.1	12.7	86.0	73.8	57.6	41.4	25.1	9.1	51.0	41.2	32.2	23.1	14.1	5.1
FFUEL	lb/hr	48.70	43.37	33 96	25.54	18.19	11.83	35.06	29.91	22.70	17.05	11.77	7.13	21.81	17.01	12.91	9.64	6.87	4.12
BSFC	lb/BHP-hr	0.418	0.419	0.421	0.440	0.519	0.935	0.408	0.405	0.394	0.412	0.471	0.787	0.428	0.413	0.401	0.417	0.487	0.819
BMEP	psi	118.8	105.5	82.2	59.1	35.8	12.9	116.0	99.6	77.7	55.8	33.8	12.3	101.8	82.3	64.3	46.1	28.2	10 2
FBLOWBY	cfm	3.94	3.89	3.74	3.56	3.40	3.32	3.57	3.54	3.42	3.35	3.32	3 23	3.33	3.36	3.31	3.33	3.24	3.24
CELL_RH	%	31.8	28.9	28.5	28.6	28.4	28.7	29.1	28.2	29.1	28.6	30.2	29.7	29.9	30.2	31.0	30.6	30.5	31 8
Temperatures																			
TCOOLIN	°F	204.6	205.7	208.0	210.0	211.7	212.8	204.5	206.3	208.4	210.3	211.9	212.7	203.6	206.8	208.1	209 8	211.2	213 0
TCOOLOUT	°F	218.1	217.9	218.1	218.1	218.3	218.0	218.3	218.2	217 9	217.9	217.6	217.6	218.2	218.0	217.3	216 9	216.9	216 8
TOILGALY	°F	190.9	194.9	197.2	204.4	211.1	215.5	199.1	201.8	205.6	207.4	208.8	215.6	200.7	208.3	205.7	198.0	229.7	222 5
TOILSUMP	°F	235.1	235.3	234.8	235.0	234.3	232.9	233.5	232.8	232 5	231.7	229.0	233.6	234.0	226.8	234.5	228.3	235.0	228 9
TDRYBULB	°F	85.9	86.4	86.9	86.7	86.4	86.0	85.8	85.8	85 5	85.4	85.3	84.7	83.9	84.1	84.3	84 0	83.5	83 0
TAIRBCOM	°F	120.1	120.2	119.9	119.7	119.6	119.9	119.3	119.3	119 3	119.9	120.9	119.7	119.5	123.0	116.2	112.4	113.6	119.6
TAIRACOM	°F	242.1	234.4	218.2	198.6	178.1	162.9	210.2	192.5	172.4	158.9	150.0	142.4	156.3	149.0	139.1	131.5	129.7	131 3
TEXHLBCK	°F	1090.9	994.2	841.3	679.6	537.1	409.9	1037.4	921.8	742 9	585.3	447.6	328.0	970.5	780.4	609.0	469.5	360.6	273.6
TEXHRBCK	°F	1094.9	989.0	830.8	667.3	526.2	404.1	1031.0	913.0	730.7	570.2	435.5	319.2	959.6	764.2	586.7	447.6	346.4	259 5
TFUELHTR	°F	125.9	106.0	104.9	107.8	103.9	103.7	131.6	115.2	125 5	120.9	117.2	121.9	146.7	134.6	134.3	144.3	136.4	136 2
TFUELIN	°F	142.9	146.7	144.2	145.2	145.2	145.0	143.2	146.3	142 5	147.1	143.1	144.7	142.6	146.5	142.0	144.8	145.6	142 9
TFUELOUT	°F	130.5	138.9	134.9	136.0	137.8	137.8	132.3	138.6	135 0	138.1	137.2	136.8	134.4	140.4	137.0	136.3	138.1	136.6
TEXHAT	°F	377.1	390.0	348.8	293.6	244.7	204.3	319.1	338.3	291.1	249.8	210.3	174.6	288.7	300.4	252.6	206.3	175.0	147.4
TEXHCYL1	°F	982.1	910.7	775.6	638.3	515.0	401.2	912.7	826.6	674.4	536.4	424.2	317.4	827.4	691.0	555.4	435.9	337.0	258.6
TEXHCYL2	°F	1028.7	932.6	788.4	646.1	521.9	398.9	951.9	845.2	692 5	553.5	434.2	323.2	849.8	696.2	564.3	444.7	345.4	263.4
TEXHCYL3	°F	1056.1	970.7	830.1	682.9	552.2	423.0	981.0	896.5	740.4	592.2	462.0	340.0	898.2	747.7	603.5	468.3	368.8	281.1
TEXHCYL4	°F	1033.3	945.8	810.9	672.0	539.2	419.4	958.8	861.1	709 8	574.4	450.1	337.3	876.1	722.1	575.2	458.2	360.5	274 3
TEXHCYL5	°F	1026.4	915.6	773.3	635.2	506.8	391.9	949.7	831.5	679 8	543.7	419.4	312.6	857.1	691.0	553.3	434.8	339.7	259 3
TEXHCYL6	°F	1024.8	936.1	792.1	647.2	517.1	392.4	962.4	848.9	692.1	557.8	433.0	319.9	875.8	710.0	567.3	451.5	350.1	270 5
TEXHCYL7	°F	1003.4	904.4	764.8	625.1	496.9	385.5	916.3	806.2	649.6	518.2	401.8	299.0	830.7	667.3	512.5	399.9	315.2	240.6
TEXHCYL8	°F	1028.3	944.6	810.2	660.4	526.0	406.2	946.4	852.0	693.7	558.3	429.2	315.6	873.0	714.4	570.2	446.4	345.7	266.7
TDYNOIN	°F	74.7	74.8	74.8	74.7	74.5	74.3	74.4	74.6	74 5	74.5	74.3	74.2	74.3	74.4	74.4	74.3	74.2	74.1
TDYNOOUT	°F	88.9	87.6	85.0	82.1	79.1	75.9	84.7	83.6	81.7	79.6	77.5	75.3	80.4	79.4	78.3	77.1	75.9	74.6
TDAYTANK	°F	82.7	83.7	83.4	82.9	82.6	82.4	81.6	82.2	81 9	81.8	81.6	81.3	80.1	80.4	80.4	80.0	80.0	80 0
Pressures																			
POILGALY	psig	38.5	38.2	37.9	37.1	36.9	37.0	28.7	28.5	28.1	28.1	28.4	27.0	17.4	17.8	17.0	18.2	15.4	16.4
PFUEL	psig	4.4	4.5	4.7	4.9	5.1	5.3	4.9	5.0	5 2	5.3	5.5	5.6	5.4	5.5	5.7	5.7	5.8	5 8
PAMBIENT	psia	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
PINTBC	psia	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14 3	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
PINTAC	psig	9.7	8.9	7.5	5.8	4.0	2.7	6.7	5.3	3.7	2.6	1.8	1.3	2.2	1.6	1.2	0.9	0.7	0 5
PINT_RST	psig	0.06	0.06	0.06	0.05	0 04	0.04	0.03	0.03	0.02	0.02	0.02	0 02	0.0	0.0	0.0	0.0	0.0	0 0
PEXHAT	psig	0.10	0.09	0.07	0.05	0 03	0.02	0.03	0.02	0.00	0.00	-0.01	-0 02	0.0	0.0	0.0	0.0	0.0	0 0
PCOOL	psig	11.6	11.6	11.5	11.2	11.1	11.0	11.3	11.1	10 8	10.7	10.6	10.4	10.8	10.5	10.4	10.2	10.1	9.7

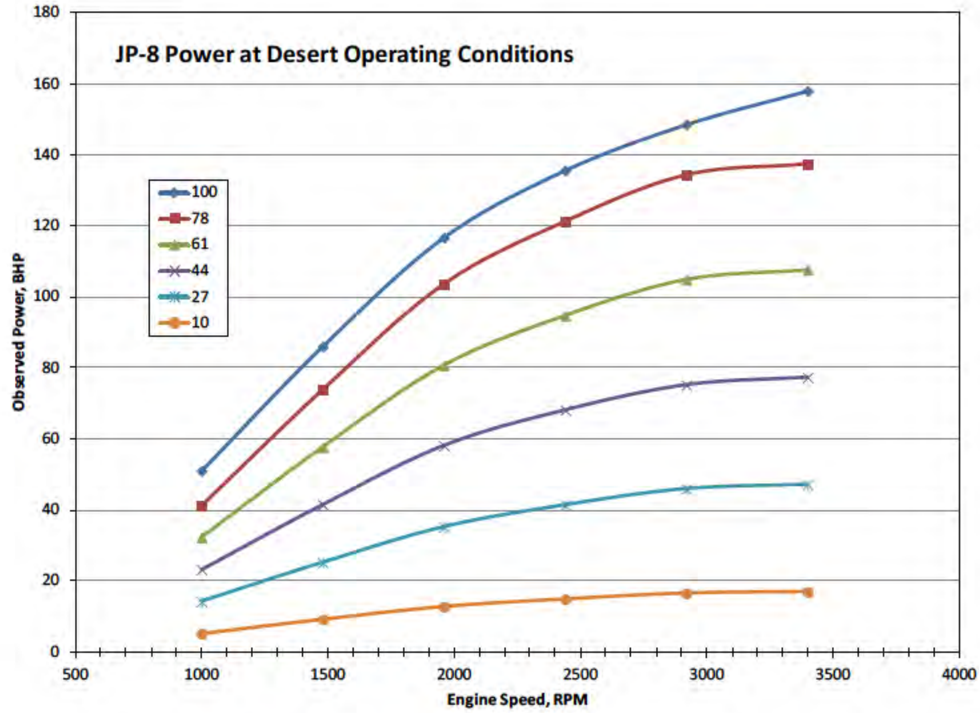

Figure 11. Observed Power with JP-8 at Desert Operating Conditions

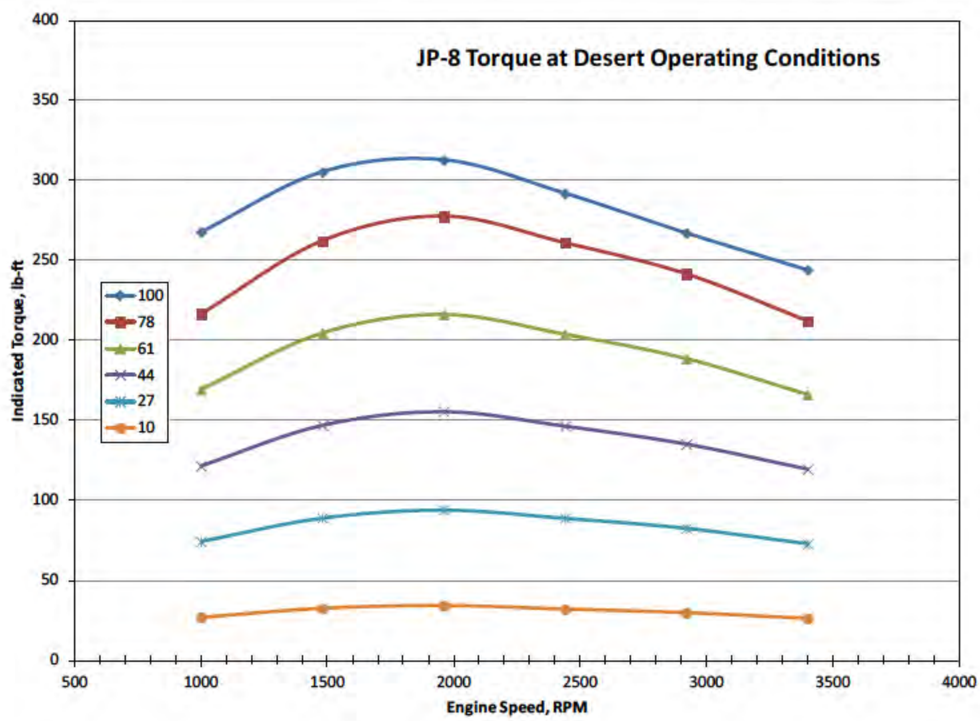

Figure 12. Indicated Torque with JP-8 at Desert Operating Conditions

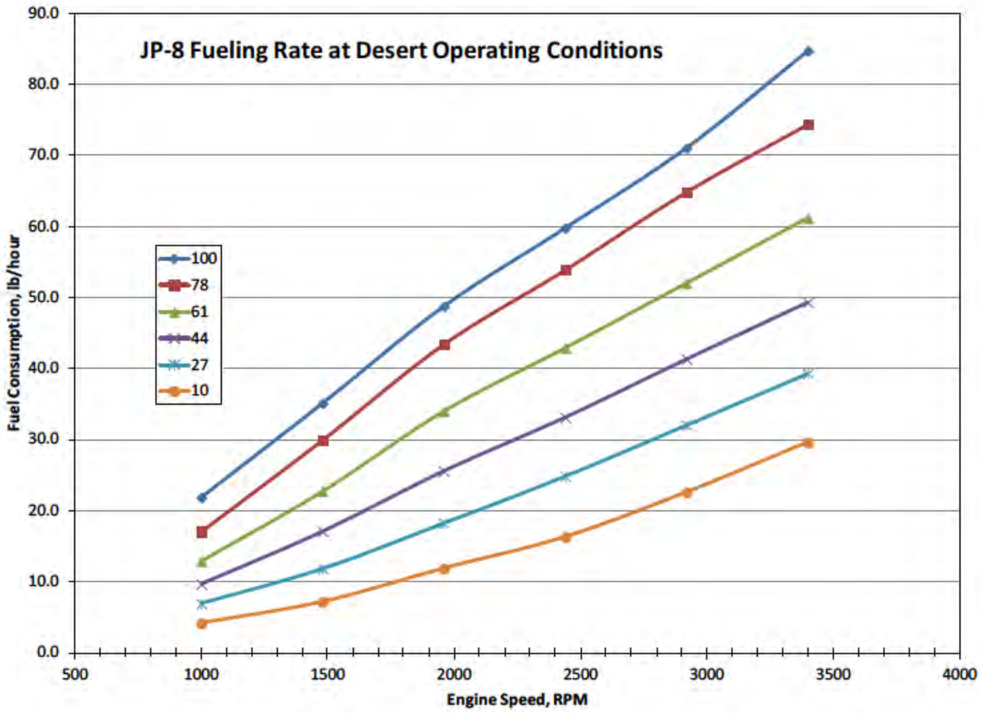

Figure 13. Fueling Rate with JP-8 at Desert Operating Conditions

4.1 Brake specific fuel consumption

The Brake Specific Fuel Consumption, or BSFC, calculated by dividing the fuel delivery by the observed power, and is a measure of engine efficiency. Different fuels and operating conditions can affect engine efficiency and subsequently BSFC. Contour maps of the BSFC, in pounds/brake horsepower-hour, are shown as a function of engine speed and indicated torque in Figure 14 for the JP-8 fuel at the ambient operating conditions. The corresponding BSFC contour map for the JP-8 fuel at the desert operating conditions is shown in Figure 15. The engine exhibited similar peak torques at each engine speed, with the ambient JP-8 producing more peak torque than with the desert condition JP-8 fuel. The region of peak efficiency of the engine, the area of lowest BSFC, was very similar for both thermal inlet conditions in the GEP 6.5L turbo engine with JP-8 fuel. However with the JP-8 fuel at ambient operating conditions, the region of minimum BSFC was slightly larger. For both operating conditions with the JP-8 fuel, the engine exhibited extremely poor BSFC at high engine speeds and low loads, indicating high internal friction at high speeds.

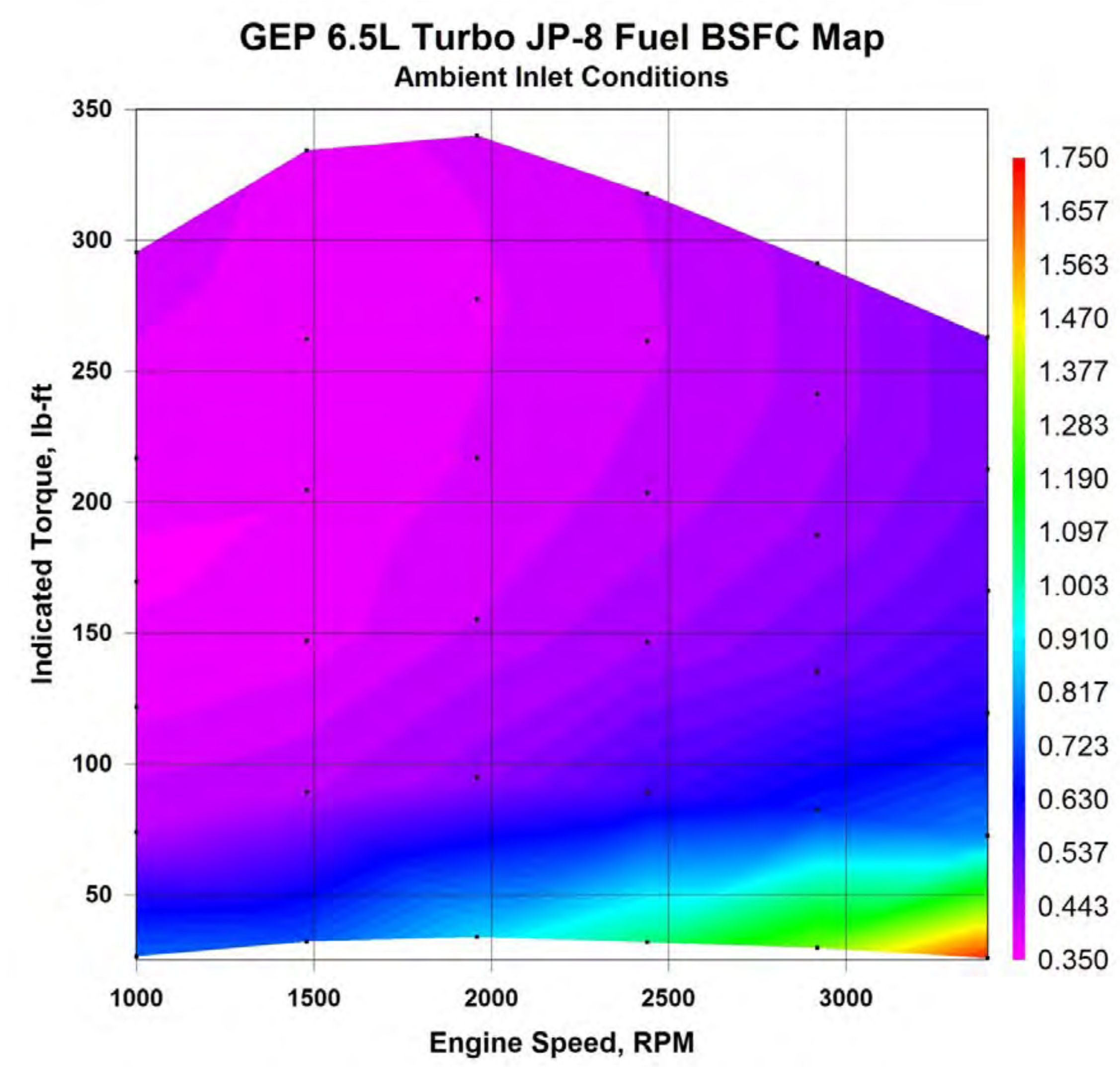

Figure 14. Brake Specific Fuel Consumption Contours for JP-8 at Ambient Operating Conditions

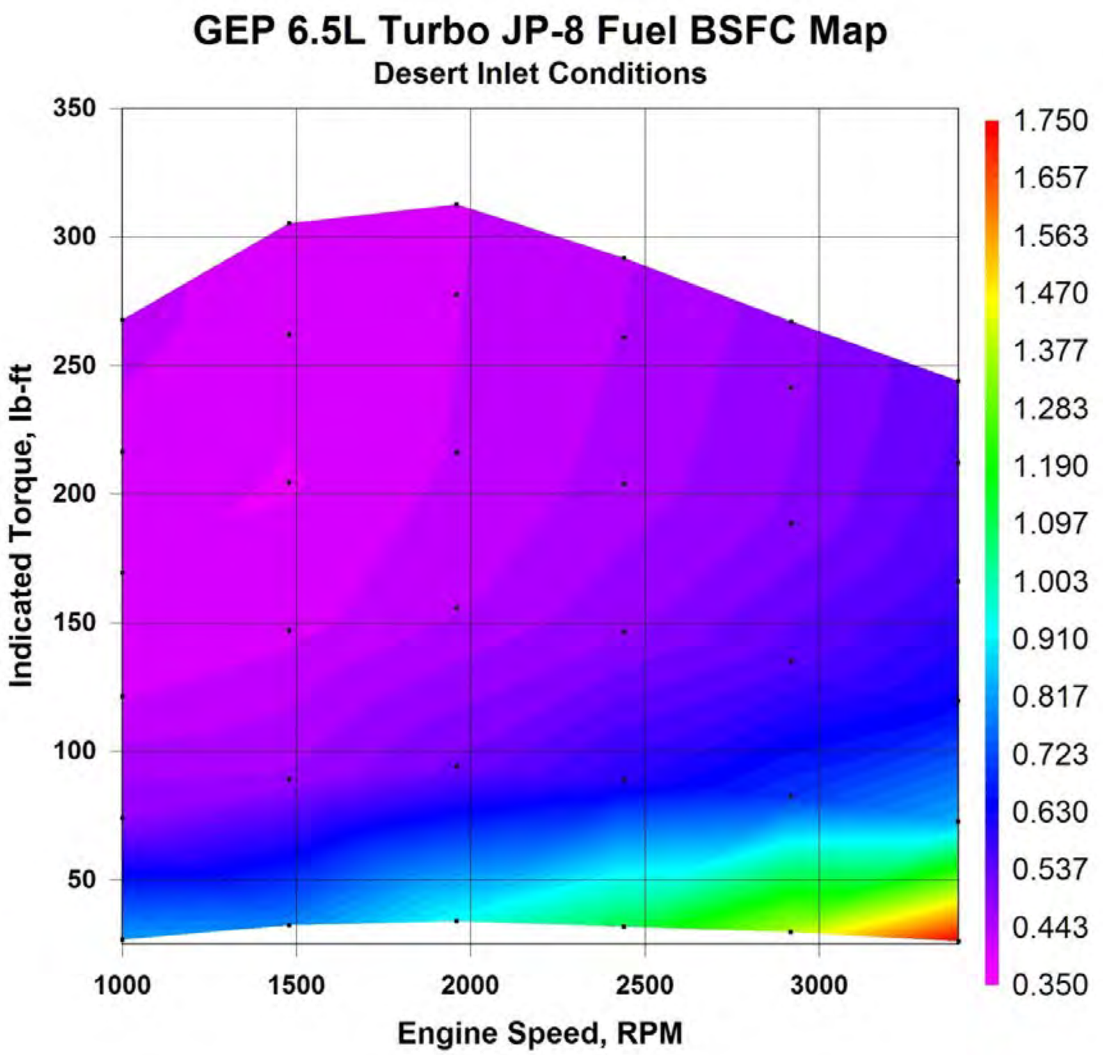

Figure 15. Brake Specific Fuel Consumption Contours for JP-8 at Desert Operating Conditions

Likewise the contour maps of the BSFC are shown as a function of engine speed and indicated torque in Figure 16 for the JP-8/ATJ fuel blend at the ambient operating conditions. The corresponding BSFC contour map for the JP-8/ATJ fuel blend at the desert operating conditions is shown in Figure 17. The engine exhibited somewhat higher peak torques at each engine speed, with the ambient operating condition JP-8/ATJ fuel blend. The desert operating condition peak torque with the JP-8/ATJ fuel blend was reduced at all speeds, but more reduction was evident at the higher engine speeds. The region of peak efficiency of the engine, the area of lowest BSFC on the map, was similar for both thermal inlet conditions in the GEP 6.5L turbo engine with the JP-8/ATJ fuel blend. However with the JP-8/ATJ fuel at ambient operating conditions, the area

of the region of minimum BSFC was larger. As with the JP-8 fuel, for both operating conditions with the JP-8/ATJ fuel, the engine exhibited extremely poor BSFC at high engine speeds and low loads, highlighting the high internal friction effects on efficiency at high engine speeds.

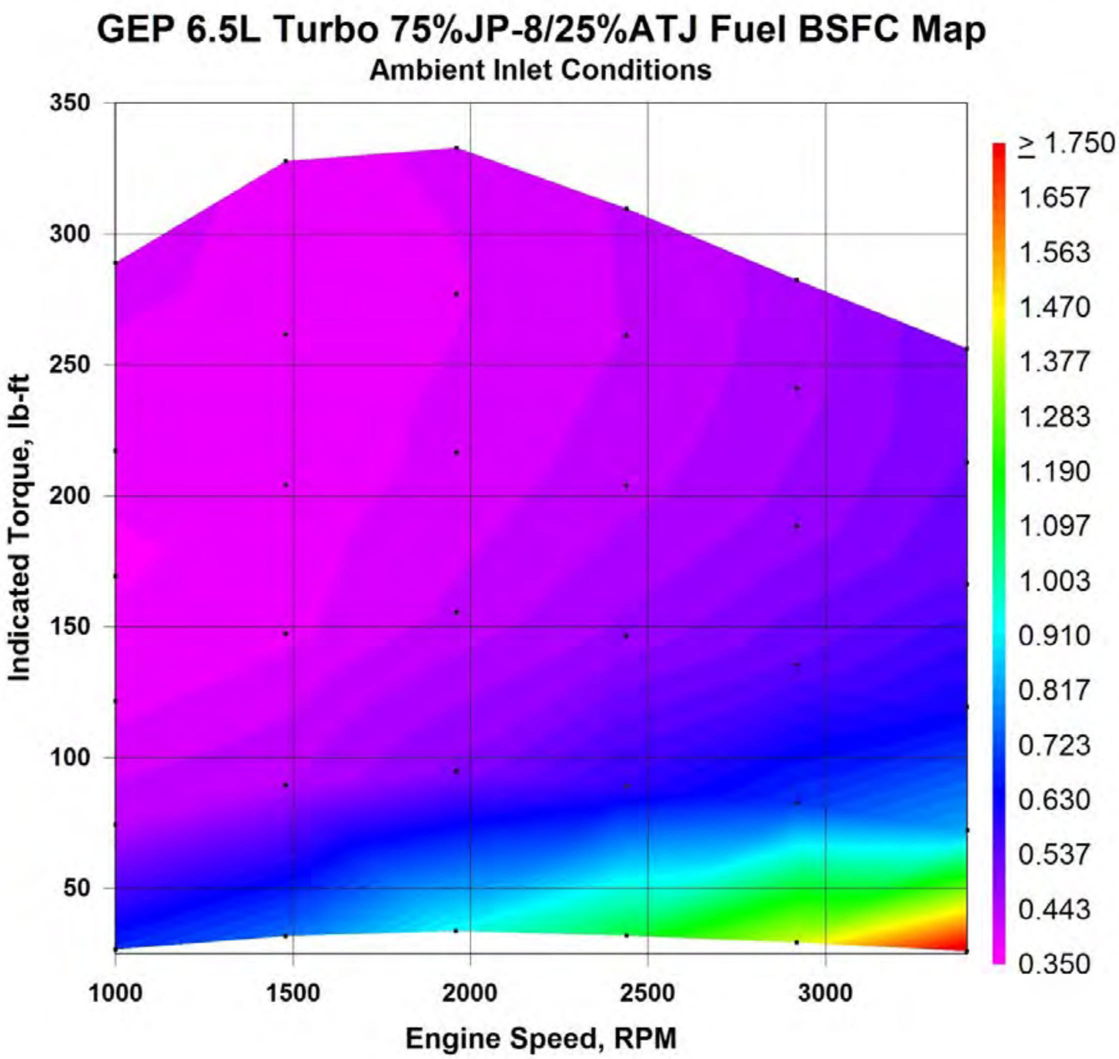

Figure 16. Brake Specific Fuel Consumption Contours for JP-8/ATJ Fuel at Ambient Operating Conditions

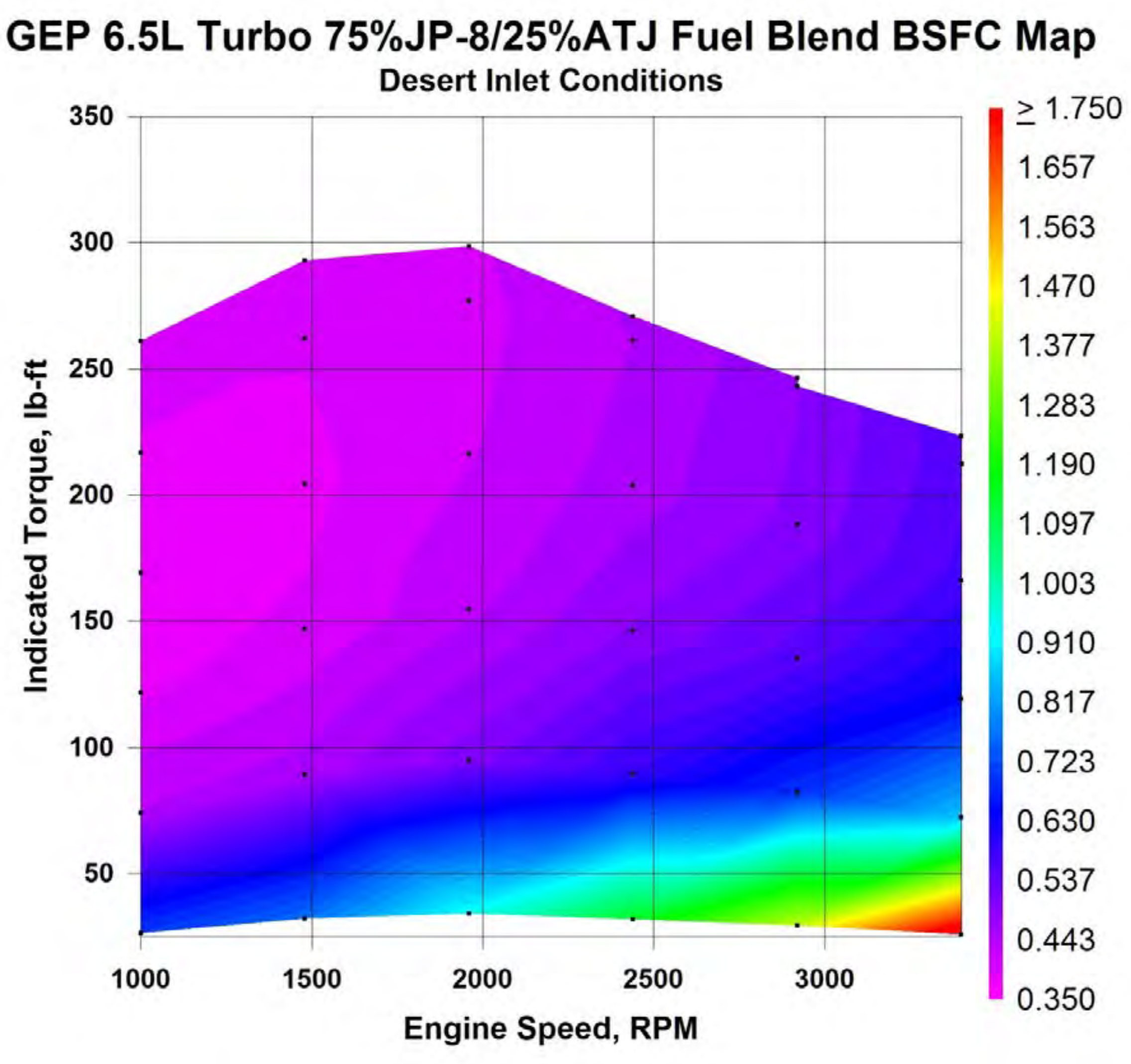

Figure 17. Brake Specific Fuel Consumption Contours for JP-8/ATJ Fuel at Desert Operating Conditions

In order to compare the engine performance across the map with regards to the fuel consumed, the BSFC for the engine operating with the JP-8/ATJ fuel blend was normalized by dividing by the JP-8 fuel performance at the same ambient inlet operating conditions. The results are shown as Figure 18, where a value of 1.0 indicates no deviation between the JP-8/ATJ and JP-8 fuels at the ambient conditions. The BSFC ratio map indicates most of the deviation was at light loads.

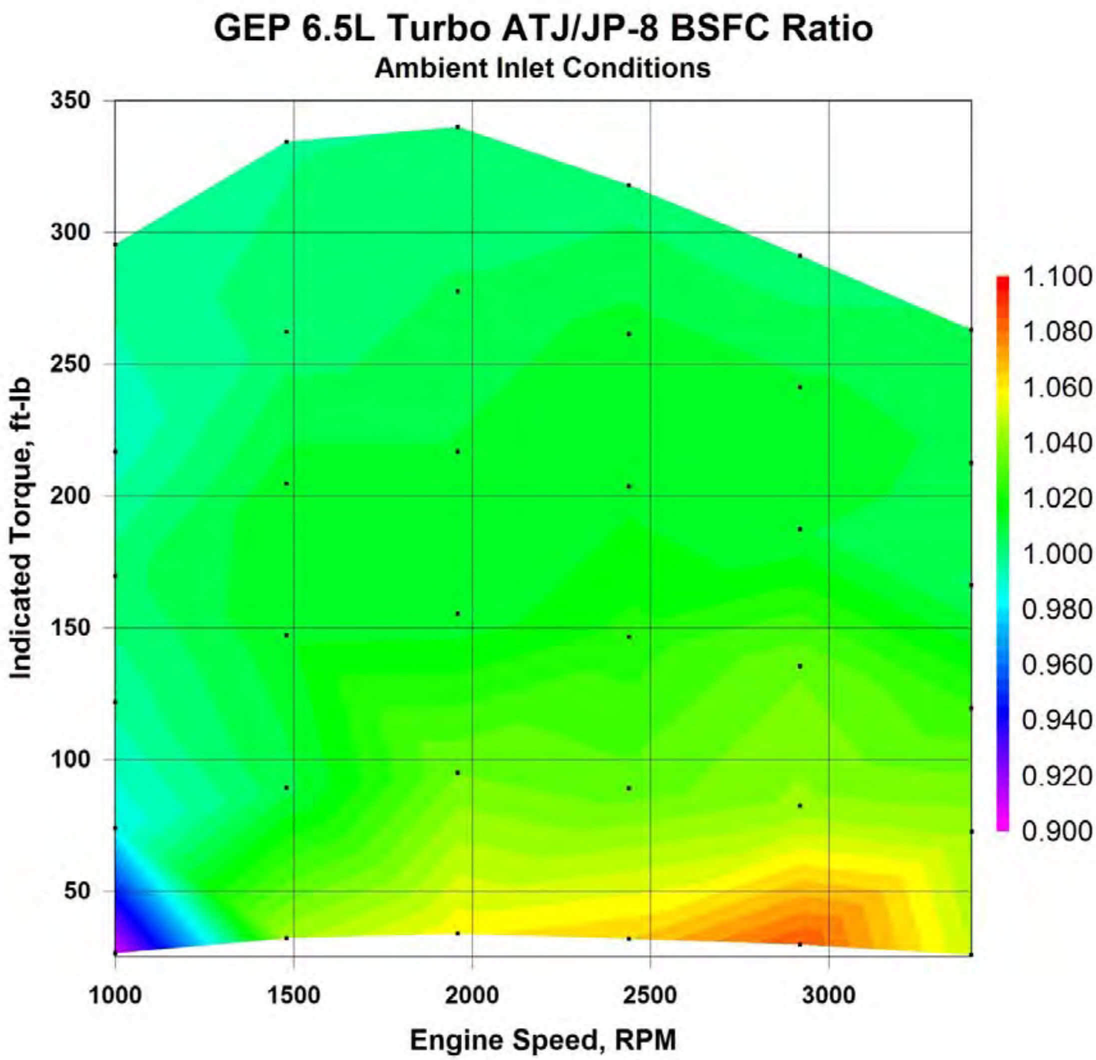

Figure 18. Contours of Ratio of JP-8/ATJ BSFC to JP-8 BSFC for Ambient Conditions

The indicated torque ratios were also calculated for the JP-8/ATJ blend at the ambient conditions by dividing by the JP-8 torque values. The results are shown as Figure 19, where a value of 1.0 indicates no deviation between the JP-8/ATJ and JP-8 fuels at the ambient conditions. For the torque ratio, the values at part loads were similar across the map, only at the full load points, and higher speeds, did the JP-8/ATJ fuel blend deviate. Maximum torque deviation was around 3% due to the JP-8/ATJ fuel blend at ambient conditions.

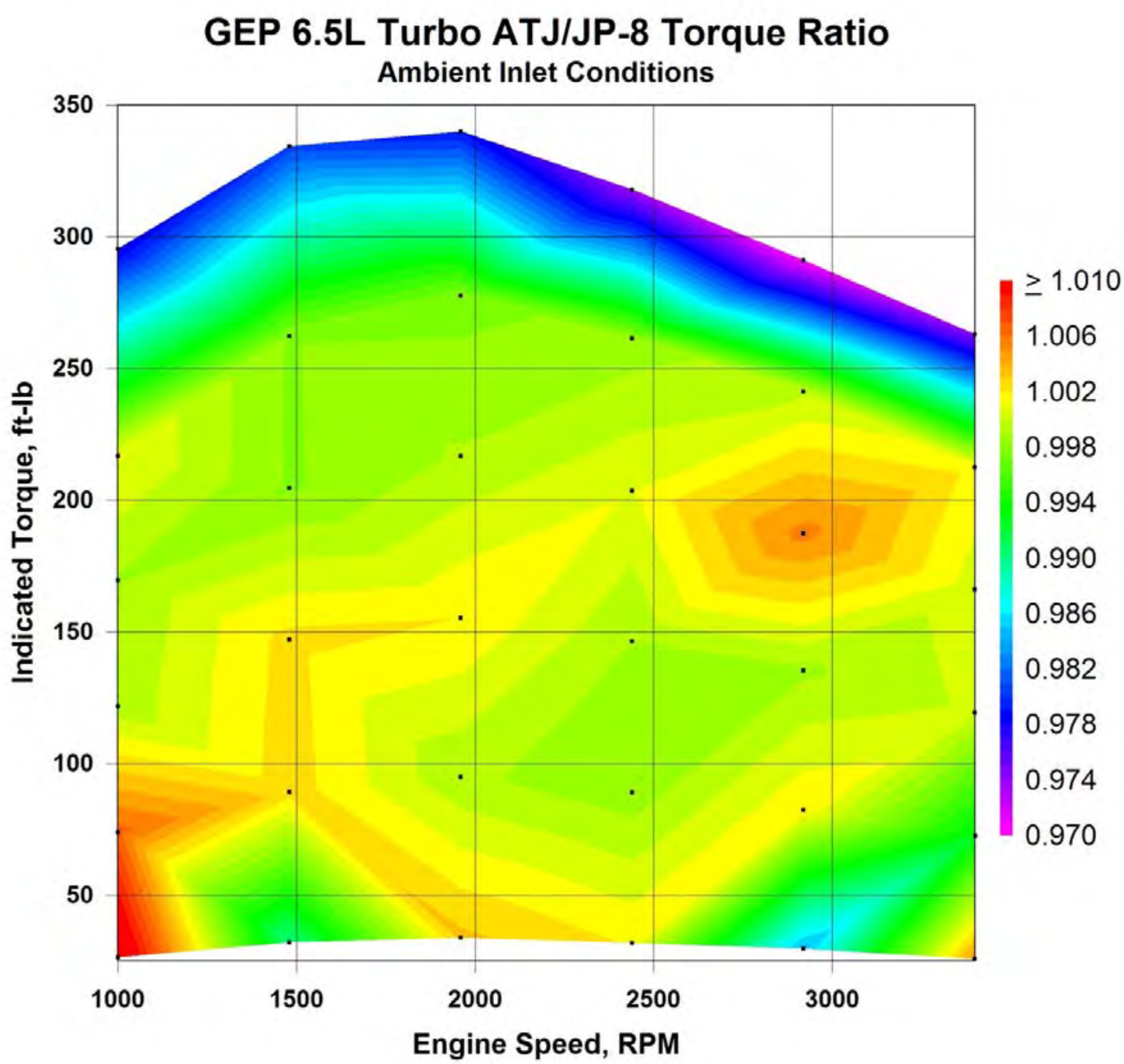

Figure 19. Contours of Ratio of JP-8/ATJ Torque to JP-8 Torque for Ambient Conditions

The indicated torque ratios were also calculated for the JP-8 fuel at desert conditions divided by the JP-8 fuel performance at the ambient conditions. The results are shown as Figure 20, where a value of 1.0 indicates no deviation between the JP-8 desert and the JP-8 ambient conditions. For the torque, the part load values were similar across the map, indicating the part load target values were consistently run, only at the full load points did the performance differ between the two thermal operating conditions with JP-8 fuel. Maximum torque deviation was around 9% at the lower engine speeds due to the desert operating condition with JP-8 fuel.

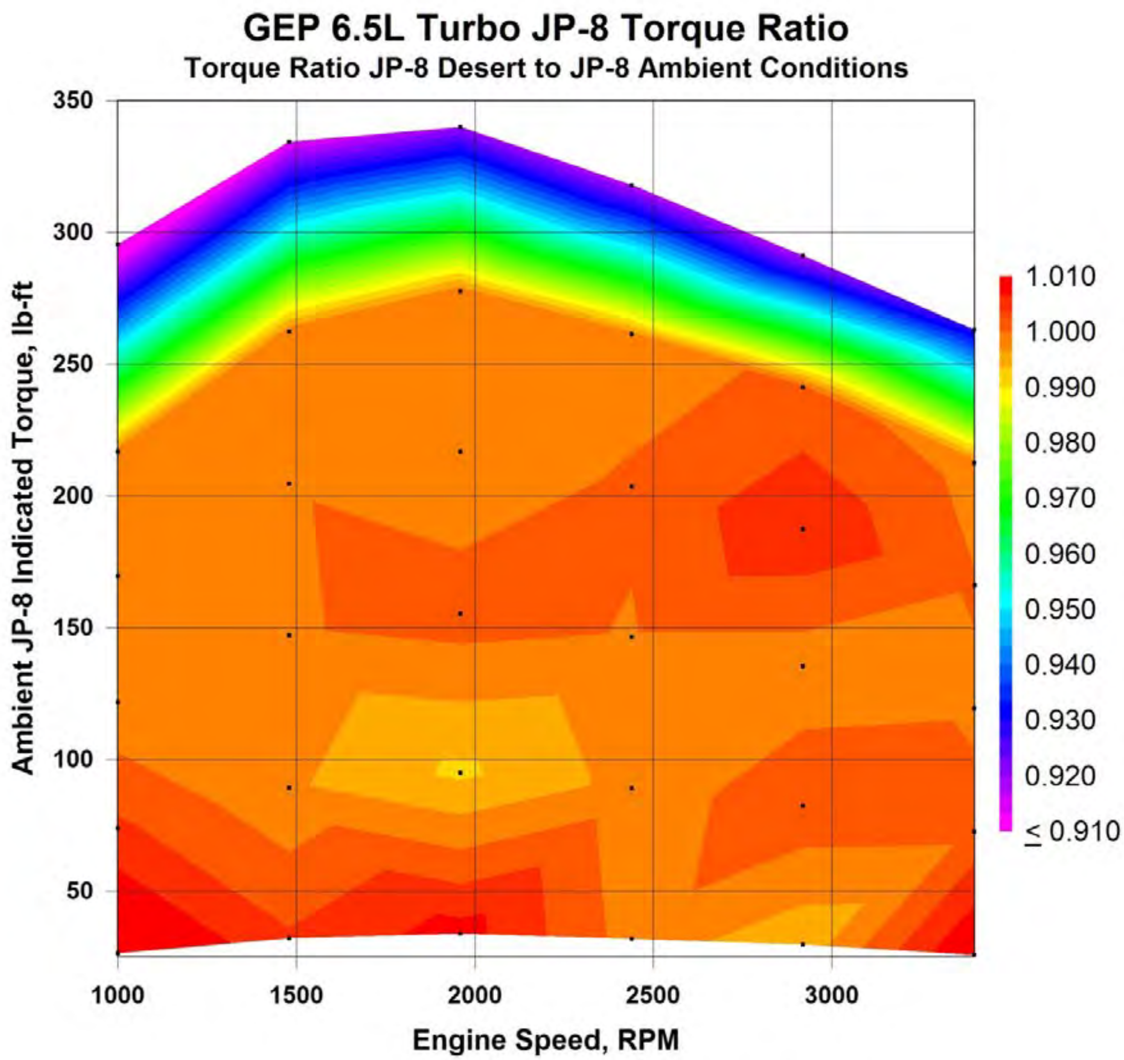

Figure 20. Contours of Ratio of Desert JP-8 Torque to Ambient JP-8 Torque

To compare the operating condition effects on engine performance across the map, the BSFC for the engine operating with the JP-8 at desert conditions was normalized by dividing by the JP-8 BSFC from the ambient inlet operating conditions. The results are shown as Figure 21, where a value of 1.0 indicates no deviation between the JP-8 at desert and the JP-8 at ambient conditions. The BSFC ratio map indicates the BSFC was higher across the whole engine map for the desert operating conditions with the JP-8 fuel.

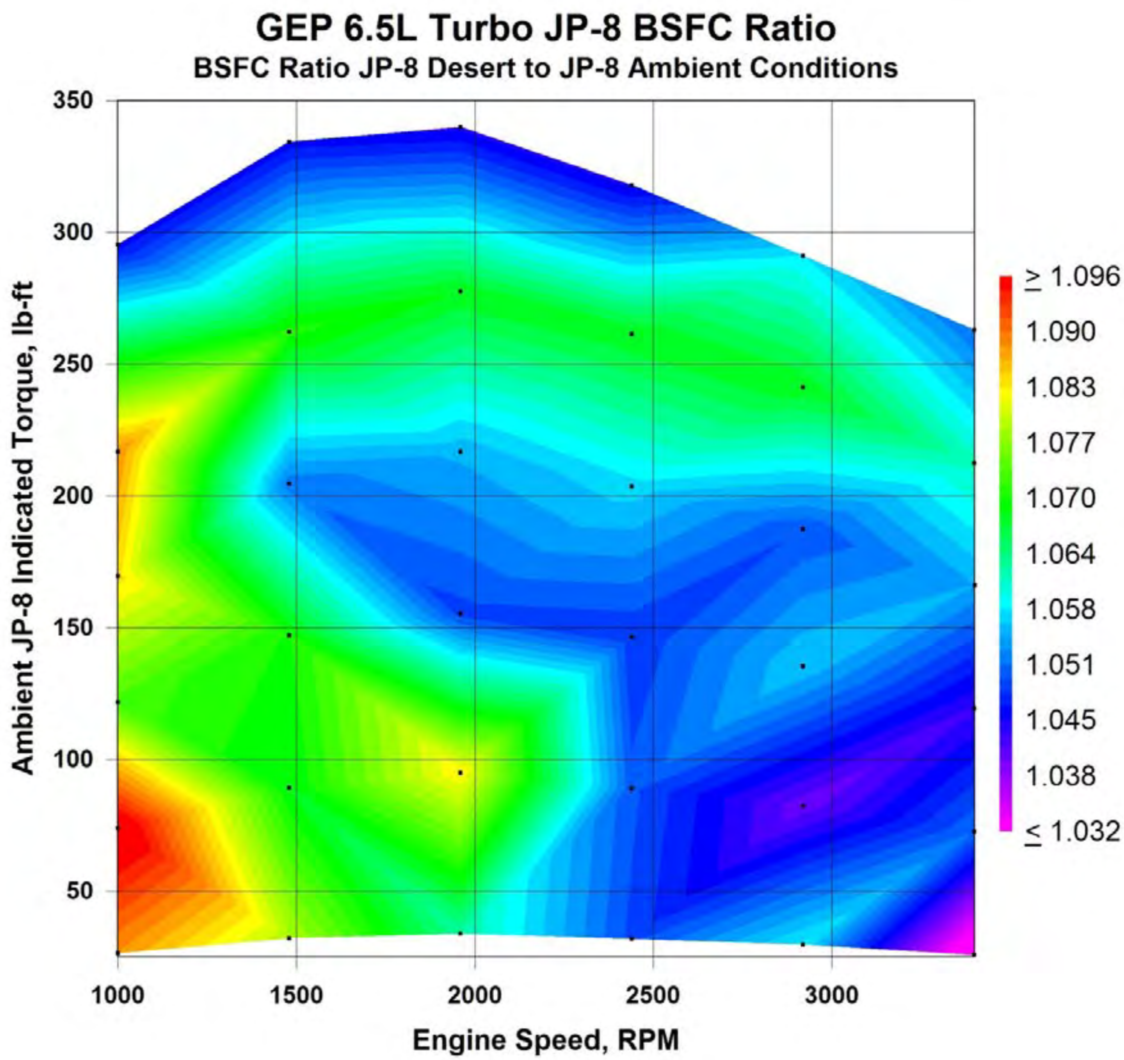

Figure 21. Contours of Ratio of Desert JP-8 BSFC to Ambient JP-8 BSFC

To compare the operating condition effects on engine performance across the map, the BSFC for the engine operating with the JP-8/ATJ fuel blend at desert conditions was normalized by dividing by the JP-8/ATJ fuel blend BSFC from the ambient inlet operating conditions for the same load points. The results are shown as Figure 22, where a value of 1.0 indicates no deviation between the JP-8 at desert and the JP-8 at ambient conditions. Except for a few points at the higher speeds, the BSFC ratio map indicates the BSFC was higher across the engine map for the desert operating conditions with the JP-8/ATJ fuel blend.

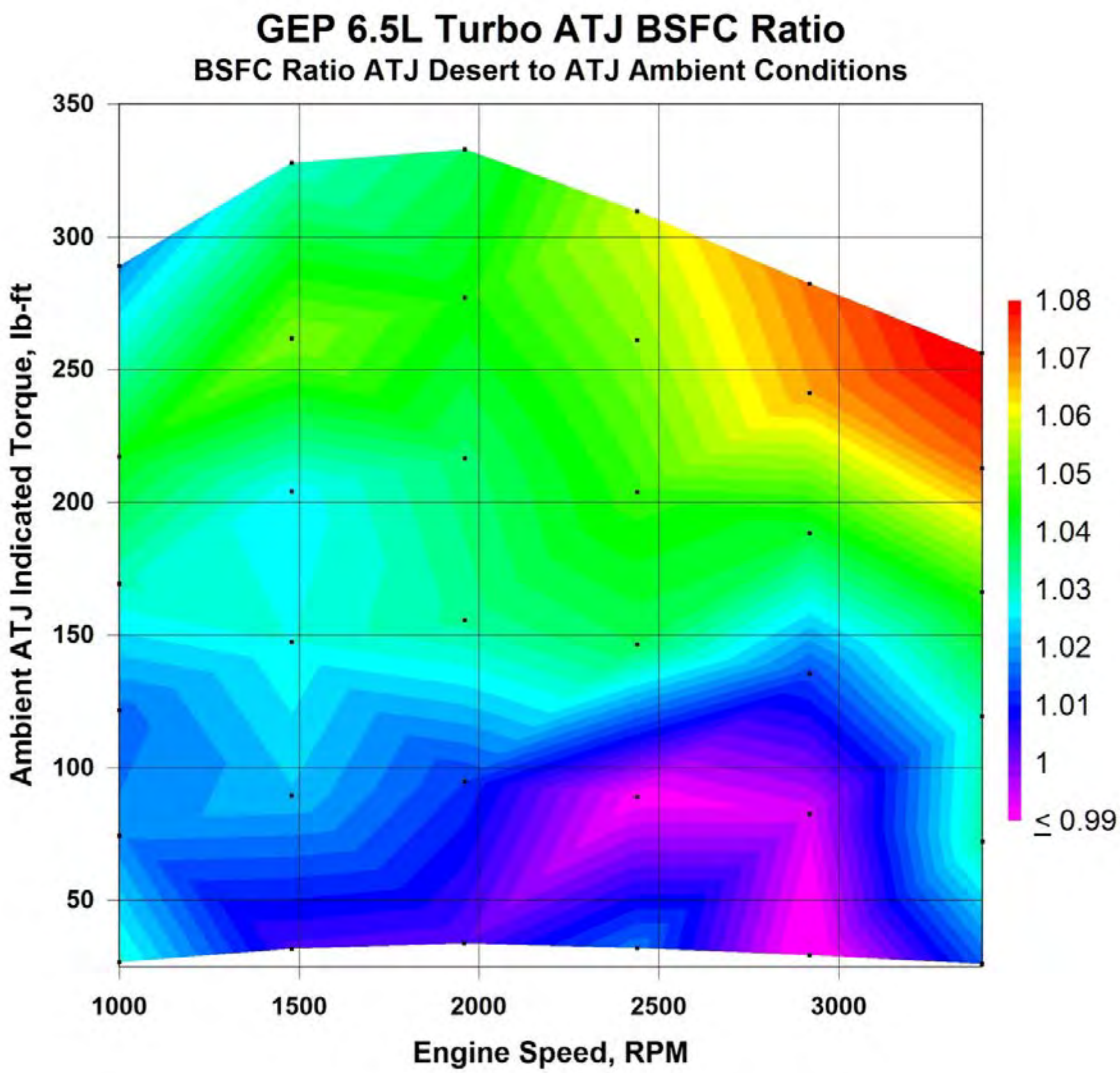

Figure 22. Contours of Ratio of Desert JP-8/ATJ BSFC to Ambient JP-8/ATJ BSFC

The indicated torque ratios were also calculated for the JP-8/ATJ fuel blend at desert conditions divided by the JP-8/ATJ fuel blend performance at the ambient conditions. The results are shown as Figure 23, where a value of 1.0 indicates no deviation between the JP-8 desert and the JP-8 ambient conditions. For the torque, the part load values were similar across the map, indicating the part load target values were consistently run, only at the full load points did the performance differ between the two thermal operating conditions with JP-8/ATJ fuel blend. The maximum torque deviation was around 12% at the higher engine speeds due to the desert operating condition with JP-8/ATJ fuel blend.

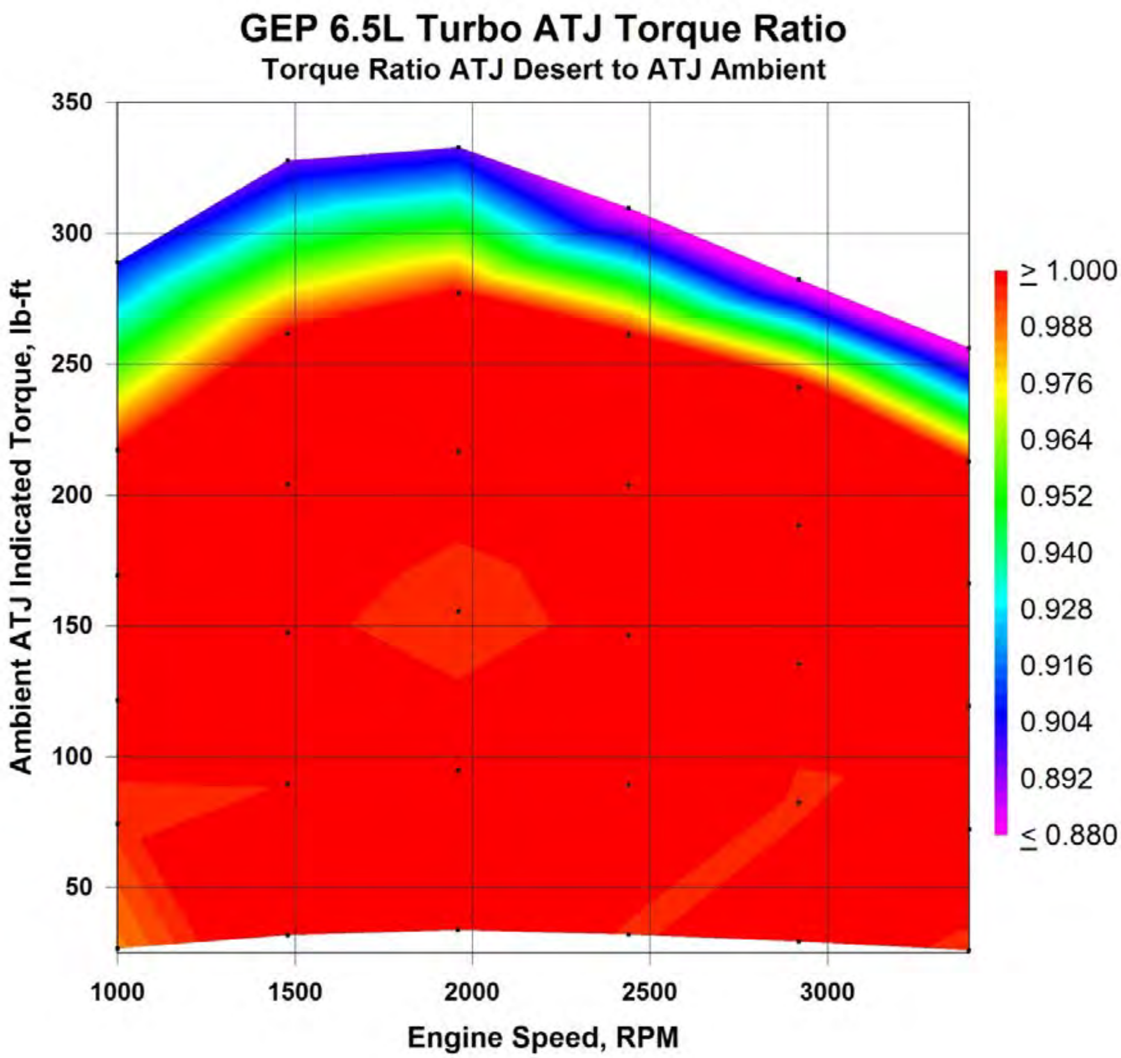

Figure 23. Contours of Ratio of Desert JP-8/ATJ Torque to Ambient JP-8/ATJ Torque

To compare the engine performance deviations due to combined inlet condition variation and fuel variation across the engine map, the BSFC for the engine operating at the desert inlet conditions on the JP-8/ATJ fuel blend was normalized by the JP-8 fuel BSFC performance at the ambient inlet operating conditions. The results are shown as Figure 24, where a value of 1.0 indicates no deviation between the desert JP-8/ATJ blend and the ambient JP-8 engine efficiency. The BSFC ratio map indicates the decreases in fuel efficiency (BSFC ratio greater than 1.0) at desert inlet conditions with the JP-8/ATJ fuel blend was across all the operating conditions except for the lightest loads at the lowest engine speed.

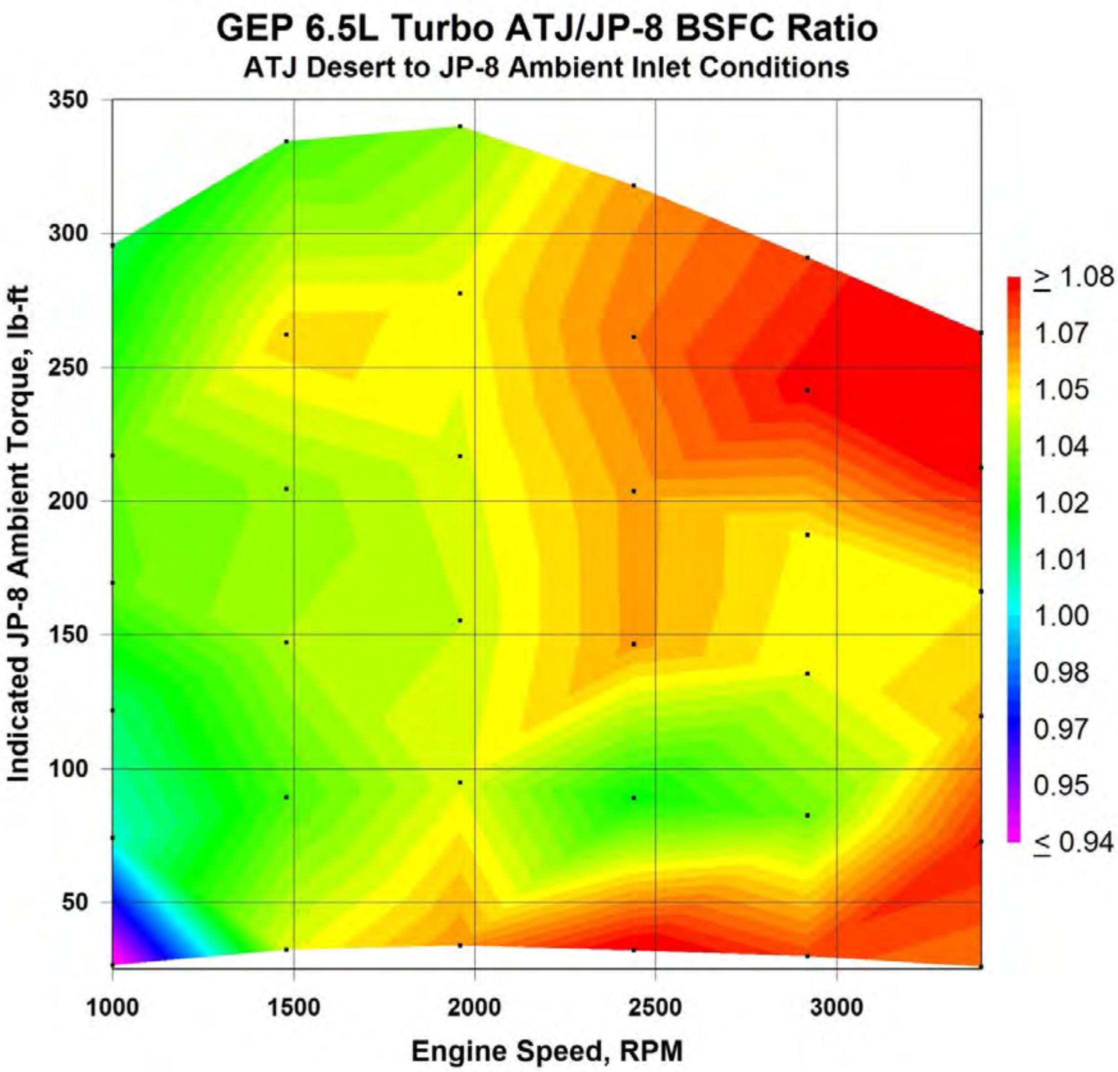

Figure 24. Contours of Ratio of Desert JP-8/ATJ BSFC to Ambient JP-8 BSFC

5.0 SUMMARY OF RESULTS

5.1 ENGINE PERFORMANCE COMPARISON

For both engine maps with the JP-8 fuel and the JP-8/ATJ fuel, the GEP 6.5LT engine produced similar power with either kerosene test fuel at the ambient operating conditions. The reduction in torque with the JP-8/ATJ blend was around 3-percent at higher engine speeds. At the desert operating conditions the JP-8/ATJ fuel blend had a greater reduction in power than JP-8 at desert conditions.

5.2 BRAKE SPECIFIC FUEL CONSUMPTION

The BSFC was very similar between test fuels at the ambient operating conditions, with the region of peak engine efficiency being similar size. At the desert operating conditions the BSFC with the JP-8/ATJ fuel blend showed the greatest detrimental impact at high speeds and high loads. Both fuels exhibited worse BSFC at the desert operating condition than the ambient conditions.

5.3 OPERATING CONDITION COMPARISON

The GEP 6.5LT engine exhibited decreased full-load torque and increased BSFC with both kerosene fuels at the desert operating conditions. The largest torque reduction was 9-percent for the JP-8 fuel, and around 12-percent for the JP-8/ATJ blend, both at the desert operating conditions.

6.0 CONCLUSIONS

The GEP 6.5LT engine operating on either JP-8, or a JP-8/ATJ blend, appeared to operate satisfactorily for the ambient operating conditions, with similar peak torque values and similar engine efficiency across the speed and load range evaluated.

At the desert operating conditions there were greater detrimental impacts on full load torque and engine efficiency with the JP-8/ATJ fuel blend than with the JP-8 fuel itself. The deviation in indicated torque between the test fuels was 3-percent, regardless of test temperature.

7.0 REFERENCES

1. DOD Operational Energy Strategy, http://energy.defense.gov/Portals/25/Documents/Reports/20120306_OE_Strategy_Implementation_Plan.pdf